Calhoun: The NPS Institutional Archive
DSpace Repository

Theses and Dissertations | 1. Thesis and Dissertation Collection, all items

1986-06

Economic analysis: an approach to provide basic guidance for conducting and reviewing economic analysis within the Venezuelan Navy.

Jimenez, Marco

http://hdl.handle.net/10945/21802

Copyright is reserved by the copyright owner

Downloaded from NPS Archive: Calhoun

Calhoun is the Naval Postgraduate School's public access digital repository for research materials and institutional publications created by the NPS community. Calhoun is named for Professor of Mathematics Guy K. Calhoun, NPS's first appointed -- and published -- scholarly author.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

http://www.nps.edu/library

CALIFORNIA 93943-5002

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

ECONOMIC ANALYSIS: AN APPROACH TO PROVIDE BASIC GUIDANCE FOR CONDUCTING AND REVIEWING ECONOMIC ANALYSIS WITHIN THE VENEZUELAN NAVY

by

Marco Jimenez

June 1986

Thesis Advisor: Fenn Horton

Approved for public release; distribution unlimited

T230809

REPORT DOCUMENTATION PAGE

EPORT SECURITY CLASSIFICATION CLASSIFIED	1b. RESTRICTIVE MARKINGS
ECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
ECLASSIFICATION/DOWNGRADING SCHEDULE	
RFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)

AME OF PERFORMING ORGANIZATION val Postgraduate School	6b OFFICE SYMBOL *(If applicable)* Code 54	7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School
DDRESS *(City, State, and ZIP Code)* nterey, California 93943-5000		7b. ADDRESS *(City, State, and ZIP Code)* Monterey, California 93943-5000
AME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL *(If applicable)*	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
DDRESS *(City, State, and ZIP Code)*		10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

TITLE *(Include Security Classification)* ECONOMIC ANALYSIS: AN APPROACH TO PROVIDE BASIC IDANCE FOR CONDUCTING AND REVIEWING ECONOMIC ANALYSIS WITHIN THE NEZUELAN NAVY

PERSONAL AUTHOR(S)
imenez, Marco

TYPE OF REPORT ster's Thesis	13b TIME COVERED FROM ________ TO ________	14 DATE OF REPORT *(Year, Month, Day)* 1986 June	15 PAGE COUNT 98

SUPPLEMENTARY NOTATION

COSATI CODES			18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
FIELD	GROUP	SUB-GROUP	Venezuelan Navy, Economic Analysis

ABSTRACT *(Continue on reverse if necessary and identify by block number)*

his thesis provides an introduction to the concepts of economic analysis, ncluding a methodology for its practical use. The intention is to prote the uniform application of economic analyses within the Venezuelan avy. Both benefit-cost and cost-effectiveness analyses are explored, ccompanied by an application of economic analysis.

DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
. NAME OF RESPONSIBLE INDIVIDUAL enn C. Horton	22b. TELEPHONE *(Include Area Code)* (408) 646-2043	22c. OFFICE SYMBOL 54Hn

FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.

Approved for Public Release; Distribution Unlimited

Economic Analysis: An Approach to Provide Basic Guidance for Conducting and Reviewing Economic Analysis within the Venezuelan Navy

by

Marco A. Jimenez Ferrer
Commander, Venezuelan Navy
B.S., Escuela Naval de Venezuela, 1970

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
June 1986

ABSTRACT

This thesis provides an introduction to the concepts of economic analysis, including a methodology for its practical use. The intention is to promote the uniform application of economic analyses within the Venezuelan Navy. Both benefit-cost and cost-effectiveness analyses are explored, accompanied by an application of economic analysis.

TABLE OF CONTENTS

I. INTRODUCTION ---------------------------------------9

  A. BACKGROUND ---------------------------------------9

  B. STATEMENT OF THE PROBLEM ---------------------------10

  C. IMPORTANCE OF THE RESEARCH -------------------------10

  D. OBJECTIVE OF THIS STUDY -----------------------------11

II. THE VENEZUELAN NAVY ECONOMIC ANALYSIS PROCESS --------12

  A. AN INTRODUCTION TO VENEZUELA -----------------------12

    1. Political History -----------------------------------12

    2. Government Structure -------------------------------15

  B. MISSION OF THE VENEZUELAN NAVY --------------------17

  C. THE VENEZUELAN NAVY RESOURCE ALLOCATION PROCESS --17

    1. The Ministry of Defense Budget Process --------------17

    2. Organizational Elements in the Venezuelan Navy Budgetary Process ---------------------------------18

      a. Estado Mayor General de la Armada (EMGAR)--Staff of the Navy ---------------------------------18

      b. Direction de Presupuesto Programacion Ecomica (DIPPE)-Direction of Budget and Economic Programming ------------------------18

      c. Comite De Programacion y Presupuesto (CPP)--Programming and Budget Committee ----------18

    3. Major Programs --------------------------------------19

    4. Budget Execution and Control ------------------------21

  D. THE VENEZUELAN NAVY DECISION-MAKING PROCESS -------21

E. THE ECONOMIC ANALYSIS PROCESS ---------------------26

III. THE CONCEPT OF ECONOMIC ANALYSIS ---------------------27

A. INTRODUCTION ---------------------27

B. ECONOMIC ANALYSIS DEFINED ---------------------28

C. USES OF ECONOMIC ANALYSIS ---------------------28

D. SECONDARY USES OF ECONOMIC ANALYSIS ---------------------31

E. ECONOMIC ANALYSIS LIMITATIONS ---------------------31

F. WHEN ECONOMIC ANALYSIS IS NOT REQUIRED ---------------------32

G. ECONOMIC ANALYSIS VERSUS PROGRAM EVALUATION ------32

H. ECONOMIC ANALYSIS ADVANTAGES ---------------------33

IV. THE ECONOMIC ANALYSIS PROCESS ---------------------35

A. INTRODUCTION ---------------------35

B. DEFINING THE OBJECTIVE ---------------------35

C. FORMULATING THE ASSUMPTIONS ---------------------37

D. IDENTIFYING THE ALTERNATIVES ---------------------38

E. ESTIMATING COST AND BENEFITS ---------------------39

F. RANKING ALTERNATIVES ---------------------41

G. SENSITIVITY ANALYSIS ---------------------43

V. COST ANALYSIS ---------------------44

A. INTRODUCTION ---------------------44

B. GENERAL COST CATEGORIES ---------------------44

1. Non-Recurring Costs. ---------------------45

a. Research and Development (R&D) ---------------------45

b. Investment Costs ---------------------45

c. Working Capital ---------------------46

d. Value of Existing Employed Assets ---------------------46

            e. Terminal/Residual Value ----------------------47
        2. Recurring Costs ----------------------------------48
        3. Life-Cycle Costs ---------------------------------48
        4. Sunk Costs ---------------------------------------49
        5. Opportunity Costs --------------------------------49
    C. OTHER COST CONSIDERATIONS ----------------------------50
        1. Documentation of Costs ---------------------------50
        2. Time Phasing of Costs and Benefits ---------------50
VI. BASIC ECONOMIC ANALYSIS TECHNIQUES ----------------------52
    A. CASH FLOW DIAGRAMS -----------------------------------52
    B. ECONOMIC LIFE --53
    C. INTEREST AND PRESENT VALUE ---------------------------54
        1. Simple Interest ----------------------------------54
        2. Compound Interest --------------------------------54
        3. Net Present Value --------------------------------54
    D. PAYBACK ANALYSIS -------------------------------------57
        1. Limitations to Undiscounted Payback --------------58
        2. Discounted Payback Method ------------------------58
    E. SENSITIVITY ANALYSIS ---------------------------------59
    F. COST-ESTIMATING TECHNIQUES ---------------------------60
        1. Benefits of Estimating Relationships -------------61
        2. Methods --61
VII. MEASURES OF EFFECTIVENESS ------------------------------63
    A. INTRODUCTION ---63
        1. Cost-Benefit Analysis ----------------------------64
        2. Cost-Effectiveness Analysis ----------------------64

    3. The Classical Theory of the Firm --------------------64
    4. Classical Operations Analysis ----------------------65
  B. COST-EFFECTIVENESS MODEL ---------------------------66
    1. The Objective (or Objectives) ----------------------66
    2. The Alternatives -----------------------------------66
    3. The Costs --66
    4. A Model (or Models) --------------------------------66
    5 A Criterion --67
  C. MEASURES OF EFFECTIVENESS --------------------------68
  D. PROBLEMS IN CHOOSING MEASURES OF EFFECTIVENESS ----69
  E. CONCLUSION ---70
VIII. CONCLUSIONS ---72
APPENDIX A: AN APPLICATION OF ECONOMIC ANALYSIS -----------74
LIST OF REFERENCES --93
BIBLIOGRAPHY --95
INITIAL DISTRIBUTION LIST ---------------------------------96

ACKNOWLEDGMENTS

I would like to express my gratitude to Dr. Fenn Horton and Dr. Leslie Darbyshire for the assistance and guidance they provided during my pursuit of this thesis. I want to dedicate this thesis to my lovely wife, Omaira, and to my children, Rigel, Ronald, and Roger, in tribute to their patience and understanding, and the fortitude they have displayed throughout my studies at the U.S. Naval Postgraduate School. I would also like to express my thanks to Commander Kristin Hinds, of the United States Naval Reserve, for the time she devoted in assisting me with this project.

I. INTRODUCTION

A. BACKGROUND

The current economic climate in Venezuela--as in all nations--demands sound economic decisions. To make sound decisions, the decision-maker must have all information pertinent to the problem. His information must be complete, logical, and presented in an easily understood form.

Today's decisions involve complex issues, which frequently require high investment and operating costs, with varying uncertainties. The complexities of the operational environment in government are not restricted to select areas, but permeate every activity and program to the lowest level of operations. In this rapidly changing climate of available resources and operational priorities, today's decision-makers must be prepared to justify and defend both current and future needs. Economic analysis offers a useful aid in this regard.

The requirement for effective economic analyses in the Venezuelan Navy is increasing due to budget problems, interservice competition, and programs to promote wise use of money. The process of conducting and reviewing economic analysis in the Venezuelan Navy is plagued with inconsistencies. Evaluation committees, which make resource allocation decisions, employ different approaches to economic analysis. The final decisions are often adversely affected by this lack of uniformity in the procedures. The root of the problem is easy to identify: the Venezuelan Navy does not have guidelines for performing economic analyses.

B. STATEMENT OF THE PROBLEM

The Venezuelan Navy is searching for modern and improved methods of analyses to handle more efficiently the increasing levels of resources assigned to the Navy budget. Despite its growing pool of resources, the Navy must still compete with numerous other public expenditure requirements. These increasing fiscal pressures make the job of the resource manager more crucial than ever before. Decision-makers at all levels of authority are being called upon to justify their resource allocation decisions as cost effective. While at first glance, this requirement may seem unnecessarily burdensome to the decision-maker, upon reflection, the prudent individual will recognize that it is both proper and essential to effective resource management. Progress attained through informed choice is greater than that attained by chance or by hunch decisions. Consistent with this philosophy, the Venezuelan Navy strongly emphasizes sound economic justification for expenditures.

However, the Venezuelan Navy, has not yet implemented a comprehensive general policy to allow effective economic analysis and program evaluation studies. The current methods of doing business are discussed in Chapter II.

C. IMPORTANCE OF THE RESEARCH

This thesis is oriented toward the determination of adequate actions which will allow the establishment and implementation of new policies, procedures, and instructions to be used in the Venezuelan Navy as a suitable strategy to carry out economic analyses and program evaluation studies.

D. OBJECTIVE OF THIS STUDY

The purpose of this thesis is to provide basic guidance for conducting and reviewing economic analysis for:

(1) Proposed programs, projects and activities

(2) Program evaluation of ongoing activities

The methodologies demonstrated herein offer an approach the Venezuelan Navy can apply to comprehensive and continuous management reviews.

This thesis is written to be easily understood, with detailed explanations of the techniques required in preparing an economic analysis. The assumption throughout is that the reader is a novice in the field of cost/benefit analysis. The author has therefore tried to develop material from a few very basic economic and common-sense principles.

II. THE VENEZUELAN NAVY ECONOMIC ANALYSIS PROCESS

A. AN INTRODUCTION TO VENEZUELA

1. Political History

Discovered by Columbus on his third voyage to the New World in 1498, Venezuela in 1810 became one of the first South American colonies to revolt against Spain. However, it was not until 1821 that independence was achieved under the leadership of Simon Bolivar, Venezuela's native son and national hero. Venezuela was part of the Greater Columbian Federation until 1830, when it adopted a constitution of its own.

Venezuela's independent existence has been characterized by frequent periods of political instability, dictatorships, and revolts. The nation's modern era began in 1935, after the death of General Juan Vicente Gomez, who had exercised an autocratic, almost feudal rule for 27 years. [Ref. 1: p. 7]

General Eleazar Lopez Contreras assumed office upon the death of Gomez, and the Gomez Congress elected him President in early 1936. Initially coming to power as the Gomez War Minister, as President, he dismantled the Gomez regime.

General Isaias Medina Angarita became President in 1941 upon nomination by his predecessor and ratification by Congress. Medina recognized political parties, including Accion Democratica (AD), Democratic Action, which was to become the fountainhead of nearly all parties. Medina emptied the jails, recalled the exiles, eliminated press censorship, and introduced reforms in agriculture, social security, and education. As just two examples: in 1942, he implemented the Progressive Income Tax Law, and his Hydrocarbon Law of 1943 became the framework for future petroleum policy.

The AD was the major political party opposing Medina and, by 1945, it was eager for power. After the collapse of a plan for cooperation between the AD and the Medina government in the selection of Medina's successor, the AD joined with disaffected young military officers in ousting Medina before his term ended. The AD justified its actions by arguing that Medina's successor would delay democracy indefinitely. Despite military participation in the takeover, civilians dominated the Junta of military officers, and Romulo Betancourt of the AD became the interim President.

Political and economic reforms came tumbling out of Miraflores Palace. The new government wanted to change everything at once. The Junta called for popular elections of the President and Congress. New parties sprang up and labor organized. In the first free elections in Venezuelan history, Romulo Gallegos, novelist and educator, and head of the AD party, was elected President in February, 1948.

In mid-November 1948 the government of President Gallegos was overthrown. A military Junta ruled until late 1952, when General Marcos Perez Jimenez, the dominant member of the Junta, was designated President.

After 10 years of military dictatorship, the armed forces, with overwhelming popular support, deposed the Perez Jimenez Government on January 23, 1958, and formed a Junta of Government composed of three military officers and two civilians. The new Junta promptly announced that its primary objective was to establish a lawful and honest democratic regime under which individual liberties would be guaranteed. In the first hours of its existence the provisional government restored civil liberties, removed censorship, released political prisoners, and invited exiles to return. The Junta moved quickly to establish procedures for democratic elections.

The elections were held on December 7, 1958, and on February 13, 1959, Romulo Betancourt (AD) was inaugurated as President of the Republic. He was the first democratically elected President to complete his term of office and the first in a series of democratically elected Presidents. The nation had entered a new era.

In 1964, Raul Leoni (AD) was elected President and continued the policies of Betancourt, introducing new reforms. Congress increased its participation in political decision-making. In 1969, Venezuela registered another first: Rafael Caldera of the principal opposition party, the Comite de Organizacion Politica Electoral Independiente (COPEI), won the election and became President.

The successful change of political control of the government helped consolidate the democracy. In December 1973, the nation chose its fourth popularly elected President. AD regained control of the presidency when its candidate, Carlos Andre Perez, defeated 12 other presidential contenders, but in December, 1978, COPEI won the election, and Luis Herrera Campins became President. In twenty years Venezuelan politics had changed from an uncertain experiment in representative government to a robust two-party democracy with accepted norms of conduct. [Ref. 2: p. 44]

2. Government Structure

Venezuela is divided into 20 states, a federal district, two federal territories, and 72 islands in the Caribbean Sea. The National government is highly centralized and is composed of separate executive, legislative and judicial branches. Venezuela has a written constitution; the last one was adopted in 1961 and is the twenty-fifth since independence. The newest constitution was designed to guarantee continued popular democracy, direct elections, checks and balances among the branches of government, and specifications of responsibilities.

The Executive Branch of the government is headed by the President, who must be a Venezuelan by birth, at least thirty years of age, and not a member of the clergy. Elected by a plurality vote through direct and universal suffrage, the President serves a five-year term and may not be reelected until after two additional terms have passed. Ex-presidents automatically become members of the Senate. There is no Vice-President. In case of vacancy, the President of the Congress acts as chief executive until that body can select a new President.

The President directs all foreign affairs and is Commander-in-Chief of the Armed Forces. He is assisted in his executive duties by his cabinet, the Council of Ministers. The size of this council has varied since 1958; in mid-1976 it had twenty members--eighteen Ministers, the Governor of the Federal District, and the Secretary General of the Presidency. Members of the Council of Ministers serve as a body to advise the President and as individuals to direct the operations of their respective departments. They are appointed and removed by the President, to whom they are directly responsible. [Ref. 2: p. 55]

The structure of the Venezuelan Congress closely parallels its United States counterpart. It is a bicameral body, consisting of the Senate and the Chamber of Deputies. The Senators and the Deputies are elected by direct and universal suffrage for five-year terms. Two Senators are elected from each state and two from the Federal District. There are three additional senators who serve for life--the ex-presidents, Betancourt, Caldera, and Perez.

The major functions of the Venezuelan Congress are to consider, debate, approve, reject, or alter legislation; and to oversee the Executive Branch and its agencies. Most important legislation is not initiated by the congress, however, but by the Executive Branch.

As in the United States, much of the work of the Congress is accomplished through committees. Originally, each chamber had the same ten standing committees. Two committees in each chamber deal with internal affairs and foreign relations, four committees deal with economic matters, and the remaining four consider matters of public service, such as education, tourism, and defense. The most important panel is the Delegated Committee. An interim body created by the constitution, it is composed of the President and Vice-President of Congress and twenty-one other members selected on the basis of party representation in Congress. This committee serves during periods when the Congress is adjourned and acts for the Congress in its relations with the Executive Branch. During such times, the Delegated Committee may even convene Congress in extraordinary session if necessary. [Ref. 3: p. 181]

B. MISSION OF THE VENEZUELAN NAVY

Venezuela's constitution proclaims the principles of national independence, security, peace, and stability. It advocates international cooperation, democracy, and self-determination of peoples.

The constitution asserts Venezuelan national sovereignty over all the country's land and airspace and over the territorial sea three nautical miles from the coast plus an additional nine-mile contiguous zone on the continental shelf.

The legal instrument to assure and to warrant the national defense is, according to Article 132 of the constitution, the Armed Forces, comprising the Army, Navy, Air Force, and National Guard. These service branches have been created by the state to protect its citizens and the inviolability of Venezuelan territory. [Ref. 4: p. 132] In the broadest context of the Venezuelan Armed Forces, the Navy has been assigned the following mission:

> To guarantee the national sovereignty in the maritime frontier, in the Venezuelan territorial sea and rivers and lakes zones exercising control of the contiguous zone and continental shelf with the purpose of contributing, together with the other forces, to the national defense, the stability of the democratic institutions, and the respect for the constitution and laws of the republic.

C. THE VENEZUELAN NAVY RESOURCE ALLOCATION PROCESS

1. The Ministry of Defense Budget Process

The Minister of National Defense is a cabinet member, appointed by the President. As in the United States, the budgetary process related to national defense is the responsibility of the Ministry of Defense. Since 1958, by decree of the "Junta de Gobierno," the Commandant General of each service has been responsible for the command, organization, administration, and instruction of his own branch, and each reports directly to the Minister. Although a joint staff functions in areas of concern to all four service branches, it does not interfere with the direct chain-of-command relationships between each service and the MOD.

2. Organizational Elements in the Venezuelan Navy Budgetary Process

a. Estado Mayor General de la Armada (EMGAR)--Staff of the Navy

The function of the EMGAR is to establish and prioritize Navy goals in an operative annual plan (called the POA) and to forward the plan to the Commandant General of the Navy (CONGEAR)[1] for further approval. The EMGAR staff also designs the Financial Plan of the Navy (FNP), and develops an analysis of the Navy's mission as it relates to national defense and development. This analysis is included in the annual budget.

b. Direction de Presupuesto Programacion Ecomica (DIPPE)-Direction of Budget and Economic Programming

This body suggests alterations to the budget structure of the Naval Defense Program to the CONGEAR. It translates objectives into programs and it initiates the budget formulation process. It also analyzes the requirements of the individual activities that comprise the Navy's program structure. [Ref. 5: p. 5]

c. Comite De Programacion y Presupuesto (CPP)--Programming and Budget Committee

The CONGEAR presides over this committee, whose members include the Directors of the major staff offices and fleet and Marine Corps representatives. Members of the CCP review the findings of the DIPPE during the budget formulation process, and they initiate financial adjustments and grant final approval of the budget.

---

[1] The acronym abbreviates the Commandant's Spanish title, *Commandant General de la Armada*

3. Major Programs

The Venezuelan defense structure is organized according to ten major program areas (another parallel to the situation in its northern neighbor, the United States). The Venezuelan program structure breaks down as follows:

- Program 01............................Central Administration
- Program 02............................Land Defense
- Program 03............................Naval Defense
- Program 04............................Air Defense
- Program 05............................National Guard
- Program 06............................Presidential Guard
- Program 07............................Education
- Program 08............................Support Services
- Program 09............................Social Benefits

Each program has a sponsor, responsible for its overall execution and resource allocation. Each program is further subdivided into functionally based activities, which constitute the programmatic basis for resource allocation. Each activity has its own sponsor, usually the director of a major staff in the naval organization.

Each individual unit is assigned to a given activity, according to its functional responsibilities.

Of obvious interest to this particular thesis is The Naval Defense Program (Program 03). The sponsor of this program is the Navy's service chief, the Commandant General of the Navy (CONGEAR). The Naval Defense Program is subdivided into six activities. [Ref. 5: p. 8]

Activity 01: Superior Direction. This activity includes major organizational elements, with units serving functions such as advisor, staff inspection, budgeting and electronic data processing. (Sponsor: DIPPE)

Activity 02: Naval Operations. This activity includes the fleet and the Marine Corps and other direct-support activities such as intelligence, communication, and hydrographic services. (Sponsor: The Chief of Naval Operations)

Activity 03: Support Services. These include activities that support the operating commands, such as naval bases, naval stations, food services, maintenance, and facilities construction. (Sponsor: The Chief of Logistics)

Activity 04: Development and Capacitation of Human Resources (Training). This activity includes the Naval War College, Naval Postgraduate School, Naval Academy, and the Naval and Marine Corps Training Center. (Sponsor: The Chief of Education).

Activity 05: Administration of Human Resources. This activity includes programs related to military professional development, civilian personnel, the well-being of naval personnel, medical care, and naval justice. (Sponsor: The Chief of Personnel)

Activity 06: Support of Military Personnel. This activity consolidates programs relative to military pay and other benefits and compensation. (Sponsor: The Chief of Personnel).

4. Budget Execution and Control

Funds flow to the Navy from the Minister of Defense, who issues an authorization letter for all of the services.

The Navy's Director of Finances reallocates these funds to the six different activities in Defense Program 03 and establishes expense limitations for individual programs. The activities must execute and control their programs in compliance with the directives issued by the Director of Finances; specifically, the activities may not exceed the fiscal targets imposed by the DOF.

The commanding officer of each individual unit must provide a monthly statement of payments to the Director of Finances. These statements must be supported by invoices for all payments.

The Director of Finances can conduct audits of naval activities at any time. When an audit is ordered, the scope of the auditor's authority may include any or all of the following:

- Determination of whether controls are adequate and consistent with rules and directives of higher authority.
- Determination of whether accounting for receipts and expenditures is adequate.
- Checks or tests of the accuracy of reports, as well as their timeliness and usefulness.

D. THE VENEZUELAN NAVY DECISION-MAKING PROCESS

The Venezuelan Navy decision-making process can be best understood by examining an actual program. The management process for acquisition of naval ships from countries with shipbuilding industry as it is presently performed by the Venezuelan Navy provides a good illustration. This process has its fundamental basis in the Ministry of Defense (MOD) Directive D-MD-EMC-715-02, issued on June 11, 1975.

In response to the MOD directive, the Venezuelan Navy issued its own guidance, Directive DIR-MA-CGM-0030, which was updated and reissued on April 15, 1985, as DIR-MA-CGM-0030-C. [Ref. 7: p. 1] The new Venezuelan Navy directive describes the major system acquisition process., in terms stages.

The Venezuelan Navy methodology for managing the naval ship acquisition process is described in terms of the chronological steps and is developed stage by stage. The basic stages may be defined as follows (refer to Figure 2-1):

- Statement of Need
- Operational Requirement
- Technical Requirement Specifications
- Bids/Evaluation
- Project Definition and Contract Definitization

To clarify the various stages of the acquisition process and to illustrate the sequence of the whole cycle, it is necessary to understand the organizational structure of the Venezuelan Armed Forces and particularly of the Navy.

As can be seen in Figure 2-2, the Ministry of Defense of Venezuela comprises different staff and executive organizations.

Figure 2-3 illustrates the structural organization for the Venezuelan Navy. It includes relevant organizations such as the Commandant of the Navy, the General Staff, the Juric consultor (judge advocate) and four "Jefatures"--chiefs of personnel, education, operations, and logistics.

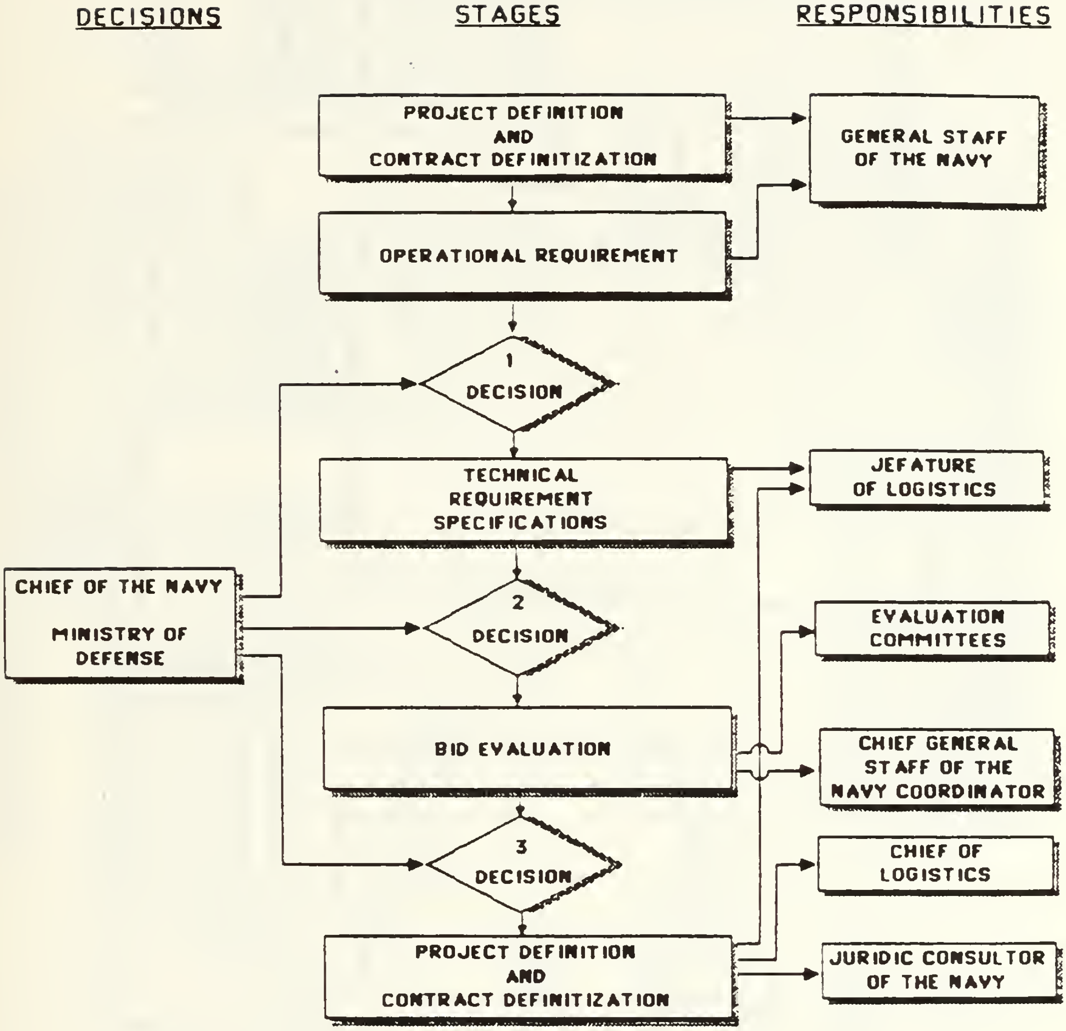
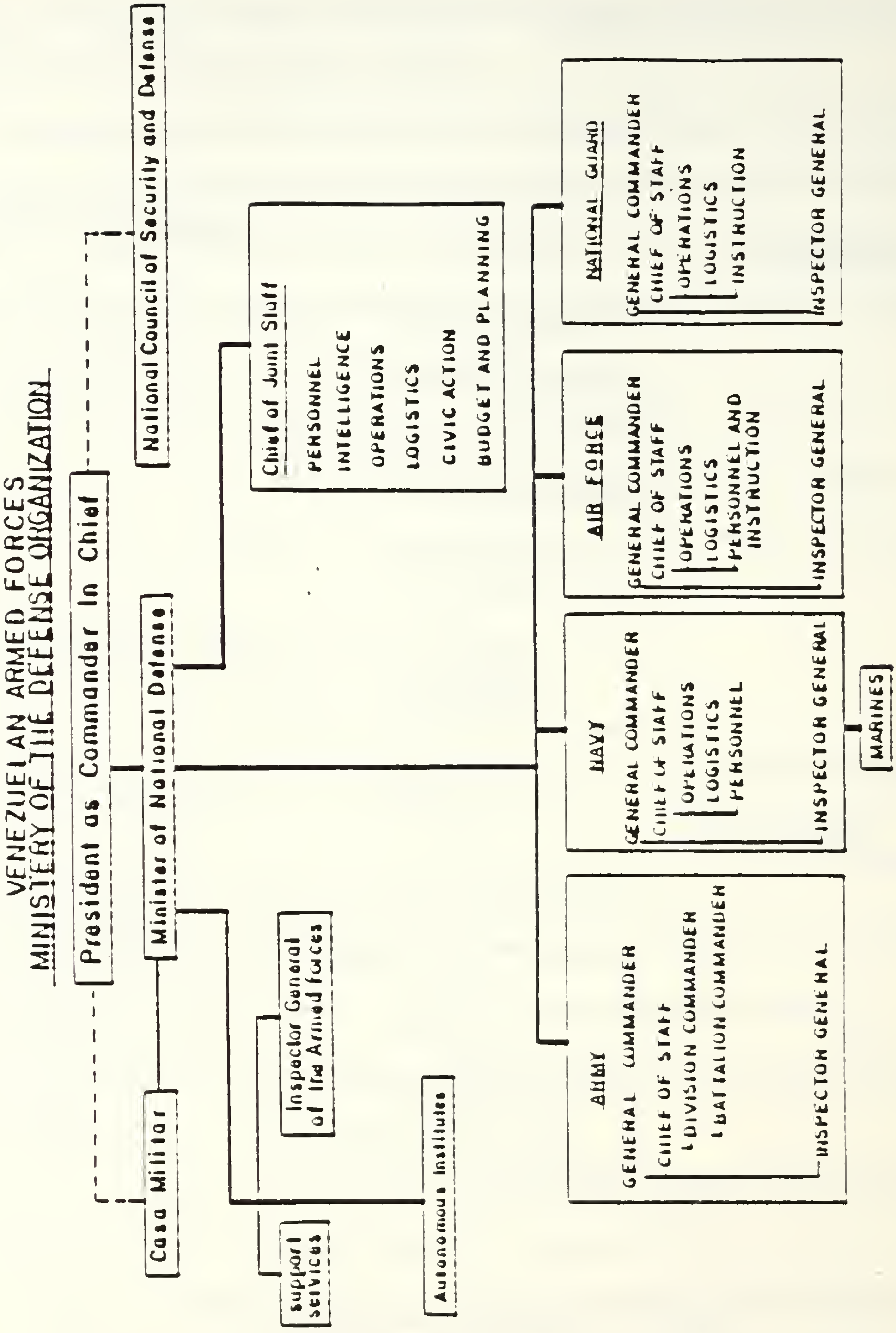

DECISIONS
STAGES
RESPONSIBILITIES
PROJECT DEFINITION AND CONTRACT DEFINITIZATION
GENERAL STAFF OF THE NAVY
OPERATIONAL REQUIREMENT
1 DECISION
TECHNICAL REQUIREMENT SPECIFICATIONS
JEFATURE OF LOGISTICS
CHIEF OF THE NAVY
MINISTRY OF DEFENSE
2 DECISION
EVALUATION COMMITTEES
BID EVALUATION
CHIEF GENERAL STAFF OF THE NAVY COORDINATOR
3 DECISION
CHIEF OF LOGISTICS
PROJECT DEFINITION AND CONTRACT DEFINITIZATION
JURIDIC CONSULTOR OF THE NAVY

Figure 2-1. Stages in the Venezuelan Naval Ships Acquisition Process



VENEZUELAN ARMED FORCES
MINISTERY OF THE DEFENSE ORGANIZATION

Figure 2.2

ORGANIZATION OF THE VENEZUELAN NAVY

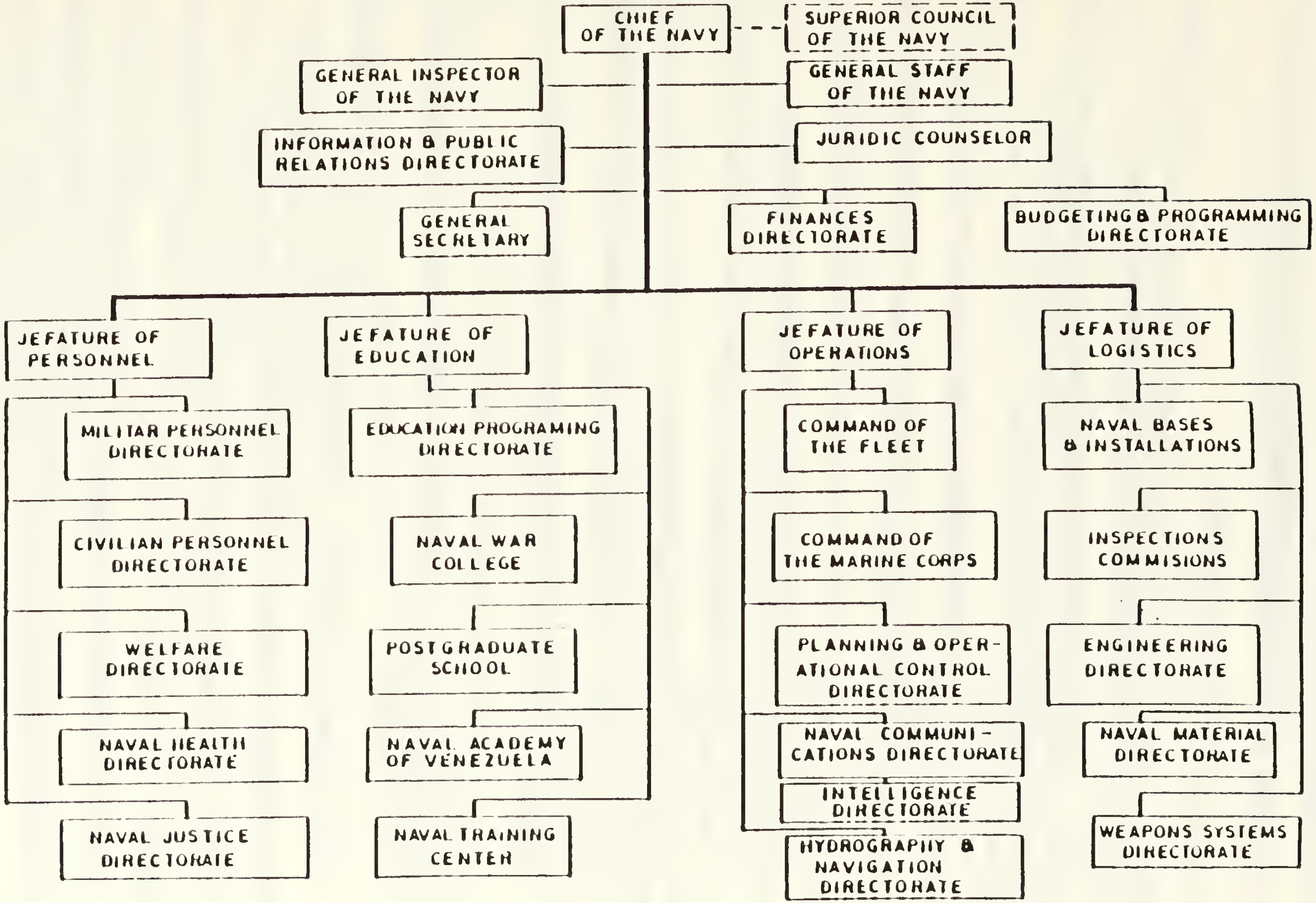

CHIEF OF THE NAVY
SUPERIOR COUNCIL OF THE NAVY
GENERAL INSPECTOR OF THE NAVY
GENERAL STAFF OF THE NAVY
INFORMATION & PUBLIC RELATIONS DIRECTORATE
JURIDIC COUNSELOR
GENERAL SECRETARY
FINANCES DIRECTORATE
BUDGETING & PROGRAMMING DIRECTORATE
JEFATURE OF PERSONNEL
MILITAR PERSONNEL DIRECTORATE
CIVILIAN PERSONNEL DIRECTORATE
WELFARE DIRECTORATE
NAVAL HEALTH DIRECTORATE
NAVAL JUSTICE DIRECTORATE
JEFATURE OF EDUCATION
EDUCATION PROGRAMING DIRECTORATE
NAVAL WAR COLLEGE
POSTGRADUATE SCHOOL
NAVAL ACADEMY OF VENEZUELA
NAVAL TRAINING CENTER
JEFATURE OF OPERATIONS
COMMAND OF THE FLEET
COMMAND OF THE MARINE CORPS
PLANNING & OPERATIONAL CONTROL DIRECTORATE
NAVAL COMMUNICATIONS DIRECTORATE
INTELLIGENCE DIRECTORATE
HYDROGRAPHY & NAVIGATION DIRECTORATE
JEFATURE OF LOGISTICS
NAVAL BASES & INSTALLATIONS
INSPECTIONS COMMISIONS
ENGINEERING DIRECTORATE
NAVAL MATERIAL DIRECTORATE
WEAPONS SYSTEMS DIRECTORATE

Figure 2.3

E. THE ECONOMIC ANALYSIS PROCESS

The purpose of describing the Venezuelan Navy resource-allocation and decision-making process is twofold:

- First, to provide the reader with a broad overview of the economic process currently employed in the Venezuelan Navy; and
- Second, to demonstrate that the Navy lacks any uniformly understood and implemented provisions to insure consistent application of economic analysis.

Managers at every level of command are being confronted daily with decisions involving the allocation of scarce resources; nevertheless, most decisions about consumption of resources are being made without full consideration of all cost and benefits (via economic analysis).

One could suggest several explanations as to why decision-makers fail to apply economic analysis techniques:

- They're unaware of the existence of appropriate analytical methods;
- They don't understand the purpose of an economic analysis;
- They're fearful of documenting the decision process;
- They believe economic analysis is meaningless or of insufficient value to justify itself.

Identifying all the reasons for non-application of economic analysis and corresponding solutions to insure its application would probably be impossible, since each decision-maker's conceptual process is unique. However, the contentions remain valid that (1) economic analysis can aid rational decision-making, and that (2) the Venezuelan Navy can only benefit by establishing provisions to insure its informed and effective application. The remainder of this thesis will attempt to prove these contentions.

III. THE CONCEPT OF ECONOMIC ANALYSIS

A. INTRODUCTION

Economic analysis is concerned with choice. It is based on the premise that every decision has a number of choices or alternative ways in which to successfully achieve an objective. Specific decision problems will vary, as well as the choices for their solution; economic analysis provides a guideline in a choice situation where there are alternatives with measurable costs and benefits.

Economic analysis is a systematic method of evaluating alternative approaches in a given choice situation. Embedded into the evaluation of alternatives is a set of constraints and criteria by which each alternative is compared. More simply stated, economic analysis is a method of evaluating alternatives to help the decision-maker discover a solution to the decision problem.

In choosing an alternative, the decision-maker must weigh those costs and benefits in terms of tradeoffs: what will not be realized by foregoing a particular alternative. When an alternative is chosen, the benefits and costs of the other alternatives are not realized. The cost of one alternative may be expressed as the benefits that will not be realized when another alternative is chosen.

These views may be summarized as follows:

- Economic analysis is a method for evaluating alternatives.
- Economic analysis is only a tool for assisting the decision-maker in choice situations; it does not itself dictate decisions.

- Economic analysis assists decision-makers in structuring their choices within constraints and in establishing a clear criterion for evaluating those choices [Ref. 8: p. 5]

B. ECONOMIC ANALYSIS DEFINED

Economic analysis can be defined as a systematic approach to the problem of choosing how to employ scarce resources, including investigation of the full implications of achieving a given objective in the most efficient and effective manner. The determination of efficiency and effectiveness is implicit in the assessment of cost effectiveness of alternative approaches and is accomplished by:

- Systematically identifying the benefits and other outputs and costs associated with alternative programs, missions, and functions and/or of alternative ways of implementing a given program.
- Highlighting the sensitivity of a predicted outcome to values of the key parameters and assumptions on which decisions are based, including technical, operational, schedule and other performance considerations.
- Evaluating alternative methods of financing investments, such as leasing or buying.
- Using benefits and costs to compare the relative merits of alternatives as an aid to:
    - -- Making trade-offs between alternatives;
    - -- Recommending the most cost-effective alternatives;
    - -- Establishing or changing priorities.

C. USES OF ECONOMIC ANALYSIS

Economic analysis is generally used in two ways: (1) to assess the economic consequences of a decision already made, or (2) as part of the initial decision-making process. The distinction lies in the relationship of the analysis to the planning and decision process. Figure 3-1 illustrates this distinction.

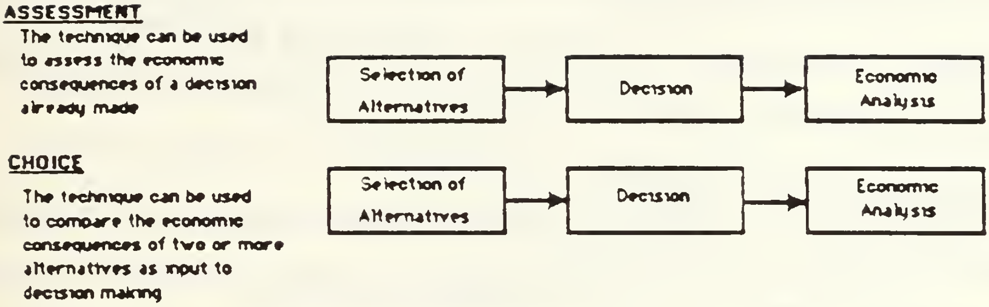

ASSESSMENT
The technique can be used to assess the economic consequences of a decision already made
Selection of Alternatives
Decision
Economic Analysis
CHOICE
The technique can be used to compare the economic consequences of two or more alternatives as input to decision making
Selection of Alternatives
Decision
Economic Analysis

Figure 3-1. Uses of Economic Analysis

In analyzing the economic impacts of a previously made decision, it is assumed that a given decision, or set of decisions, has indeed been made. The results of the economic analysis can then be used to determine future courses of action.

In applying economic analysis to initial decision-making, however, it is assumed that the decision itself will depend on the economic consequences of two or more alternatives. In this case, a decision would not be made until all costs and benefits of each alternative are estimated. [Ref. 9: p. 1-2]

Economic analysis is not intended to be an absolute determinant of a particular course of action or project. It is merely a tool by which more factors may be quantified to assist the decision-maker. The decision-maker must interpret the results of the analysis in light of any additional information (for example, political constraints, non-economic objectives) that may not have been considered in the analysis.

Economic analysis is of importance to any person involved in allocation of funds or other resources, such as manpower or hardware.

The possible benefits accruing from such analysis are many. It can assist in the evolution of cost and benefit data and effecting a more precise comparison of alternative courses of action. As a consequence, it can thereby help determine better solutions to investment problems.

The use of rigorous and systematic economic analysis can result in a better allocation of resources through improved visibility of the economic aspects of programs and projects. Since economic analysis is a general procedure, it can be used to help solve a wide range of problems, from simple to complex. [Ref. 10: p. 1-2] If properly used, it can provide a given set of outputs or potential outputs for less cost.

D. SECONDARY USES OF ECONOMIC ANALYSIS

While the primary purpose of an economic analysis is to aid the decision-maker in choosing a course of action from among alternatives, it can also serve other purposes.

The economic analysis can be a benchmark for future program evaluations.

Economic analyses can be useful to the budgeteer in determining future funding requirements.

The economic analysis serves as visible evidence to higher echelons of review and approval that economic factors bearing on the recommended decisions have been duly considered. Thus, it also plays a role in project documentation. [Ref. 10: p. 1-3]

E. ECONOMIC ANALYSIS LIMITATIONS

In addition to its several advantages, economic analysis is subject to several limitations, which must be recognized if the technique is to be put to the best use.

- Economic analysis does not normally establish priorities among various goals and objectives. It merely seeks to determine the most cost-effective means of satisfying a given objective.
- Even in choosing the most preferred means of meeting an objective, economic analysis is not itself a decision-making process; it is only one input to that process. The decision-makers typically must weigh the results of the analysis against other factors, such as safety, health, morale, environmental impact, political considerations, and national priorities. In short, economic analysis is not a substitute for sound judgment. Rather, by systematically quantifying what is quantifiable, it allows the decision-maker to focus his judgment more sharply on those areas where quantification alone cannot point to the "best" decision.

- An economic analysis is only as good as the data upon which it is based; it cannot provide results more valid than the input data. Judicious formulation of assumptions and careful estimation of costs and benefits are therefore critical to the economic analysis process. Yet, no matter how much care is exercised during those stages, uncertainty cannot be eliminated completely. Economic analysis necessarily involves assumptions, projections, or estimates of future events whose outcomes cannot be known with certainty until they occur. The obvious goal of the analyst is to minimize uncertainty and to cope with it in a rational manner.

F. WHEN ECONOMIC ANALYSIS IS NOT REQUIRED

Economic analysis is not appropriate to every decision-making process. Two important guidelines apply in determining to forego this particular tool:

- Where it can be shown that the minimum level of effort required to do the analysis would exceed the benefits to be gained therefrom; and
- When proposed actions have been specifically directed by legislation or prior irrevocable management decisions that preclude any choice or trade-off among alternatives.

G. ECONOMIC ANALYSIS VERSUS PROGRAM EVALUATION

Program evaluation is economic analysis of on-going actions, with the purpose of determining how best to improve an approved program (project) based on actual performance. Program evaluation studies entail a comparison of actual performance with the approved program(project) as designed.

Economic analysis and program evaluation have different purposes. The former concept is designed to assist a manager in identifying the best new program and projects to be adopted. The latter focuses on already approved programs and projects, with the purpose of ensuring that established goals and objectives are being attained in the most cost-effective manner. [Ref. 11: p. 3]

Functional managers must understand the distinction between economic analysis and program evaluation so that they may distinguish the different type of supporting data for each purpose. By properly distinguishing and accumulating appropriate data, functional managers can reduce delays for decision-makers, as well as reduce the demands decision-makers place on the functional organizations with recurring requests for data rework.

H. ECONOMIC ANALYSIS ADVANTAGES

Numerous advantages may be derived from economic analysis, including the following.

By its nature, the economic analysis process forces a clear statement of objectives, which aids in defining the intent of the study.

Economic analysis forces the statement of assumptions upon which the analysis is performed; explicit statement of these assumptions can clarify understanding of both the problem itself and of its implications.

If done properly, economic analysis will identify and explore all feasible alternatives to the problem at hand, thereby uncovering possible solutions that might have otherwise gone overlooked.

Economic analysis also forces the decision-makers to identify and acknowledge all resources required to fulfill a given objective; in the absence of such analysis, a comprehensive identification of resource requirements often evolves only after the program in question is well into execution.

Perhaps most importantly, economic analysis offers a logical method to identify and consider a variety of alternatives to solving a particular problem; decision-makers have a broader range of information upon which to base their final choices. Moreover, it assists superiors in evaluating the work of subordinates, as well as in the audit function.

If conducted properly, economic analysis can also provide a framework for simplifying communications, both during and after the actual analytical process. All participants--analysts, decision-makers, budgeteers, and program executives--can benefit through increased information.

In sum, economic analysis never will--and never should--automate decision-making. It is not intended as a replacement for judgment, but rather as an aid thereto. As such, it can provide a systematic methodology for collecting, documenting, and transmitting pertinent information to all participants in a particular program, throughout the life of the endeavor. [Ref. 12: p. 3]

IV. THE ECONOMIC ANALYSIS PROCESS

A. INTRODUCTION

Economic analysis is a conceptual framework for systematically quantifying, portraying, and evaluating the relative worth of proposed projects. In conducting an economic analysis, the analyst uses a disciplined procedure to the fullest extent. The economic analysis procedure consists of a six-step approach; the diagram in Figure 4-1 shows the relationships of the elements of the economic analysis process. [Ref. 10: p. 2-11]

The six steps are:

1. Establishing and defining the goal or objective;
2. Formulating appropriate assumptions;
3. Searching out alternatives for accomplishing the objective;
4. Determining the costs (inputs) and the benefits (outputs) of each alternative;
5. Comparing costs and benefits of the alternatives;
6. Performing sensitivity analysis.

B. DEFINING THE OBJECTIVE

The single most important step in the analysis is the first step, defining the objective. Without a succinct statement of what is to be investigated, the analyst cannot possibly proceed in a meaningful way. A faulty or incomplete objective definition can lead to an expenditure of time, manpower, and material in developing the right solution to the wrong problem.

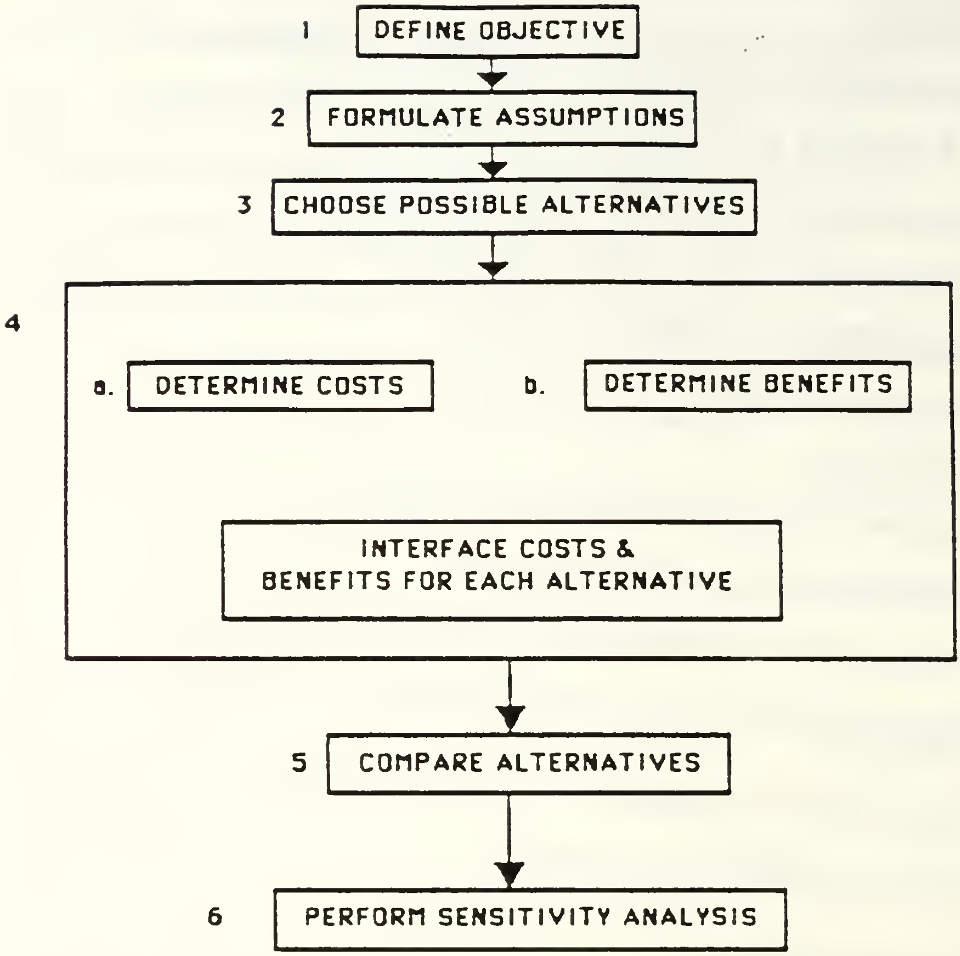

1
DEFINE OBJECTIVE
2
FORMULATE ASSUMPTIONS
3
CHOOSE POSSIBLE ALTERNATIVES
4
a.
DETERMINE COSTS
b.
DETERMINE BENEFITS
INTERFACE COSTS & BENEFITS FOR EACH ALTERNATIVE
5
COMPARE ALTERNATIVES
6
PERFORM SENSITIVITY ANALYSIS

Figure 4-1. Economic Analysis Process

Such defects are usually avoided by stating the problem in terms of a functional need, without implying how that need is to be met. The actual wording of the objective is critical in that it should reflect a totally unbiased point of view concerning how the objective may be accomplished.

In addition to clarity and lack of bias, the statement of objective should contain explicit criteria for measuring the effectiveness expected to result from the proposed concept. By stating the goal in quantitative terms, the result of the selected solution can be measured against the desired standard.

C. FORMULATING THE ASSUMPTIONS

The process of economic analysis deals with future expenditures and thus involves elements of uncertainty. A complete factual picture of an alternative under consideration may be impossible to construct, and certain assumptions may be necessary to proceed with the analysis. The purpose of the assumptions is not to limit the analysis, but to reduce often extremely complex situations to problems of manageable proportions. The analyst should be careful to match assumptions with the actual conditions under which the analysis is taking place. It is important not to confuse assumptions with facts or to attempt to simplify the analysis through use of assumptions when, with summary research, the analyst can obtain factual data. Because an assumption is an accepted "given" as opposed to a verifiable fact, it involves a degree of uncertainty. For this reason, regardless of the degree of impact they have on the analysis, all pertinent assumptions should be so identified. This assures that the decision-maker realizes the basis under which the alternatives are subsequently developed and evaluated. [Ref. 9: p. 2-3]

Common examples of assumptions include such factors as the estimated useful life of an asset, the introduction of the discount rate, and the estimated future work load.

D. IDENTIFYING THE ALTERNATIVES

The alternatives are the options or means available to the decision-maker by which the stated objectives can be attained. Depending on the particular question, alternatives may be policies, strategies, or action of any sort. Alternatives need not be obvious substitutes for one another, nor must they perform the same specific functions. In addition, the alternatives are not merely options known to the decision-maker at the start; they include whatever additional options can be discovered or thought of later.

Designating a particular alternative as the means of accomplishing the objective implies a certain set of consequences; we speak of these as the impacts associated with the alternative. Some of these impacts are benefits and contribute positively to the attainment of the objective; others are costs, negative consequence associated with the alternative, things the decision-maker wants to avoid or minimize. In addition, there may be other impacts associated with an alternative (often factors over which the decision-maker had no control) that while they have little effect, positive or negative, on the attainment of the desired objective, should nevertheless be considered in the analysis. [Ref. 13: p. 56]

The analysis of alternatives should include the following [Ref. 11: p. 6]:

- Identification and analysis of each feasible alternative with clear presentation of the costs and benefits or effectiveness associated with achieving a given objective, to the extent possible

- When comparing two or more programs/projects, or two or more ways to accomplish a particular program/project, indication of which approach is being evaluated by an identifying number, letter, or special identification.

- A distinction between "present" and "proposed." The "present" alternative seeks to identify the level of costs and effectiveness that would accrue without changing the status quo. If the "proposed" alternative represents a cost savings, it will be the difference between the discounted recurring cost of approved program/project and the discounted recurring cost of each "proposed alternative," plus the present value of savings expected from eliminating modification or refurbishment costs for the "present" alternative. (Refer to Chapter VI for more detail concerning discount and present value.)

- Where alternative methods of financing are available, a comparative cost analysis to show that the lowest cost method of acquisition has been considered.

Often, the analyst preparing an economic analysis is directed to select alternatives that keep the solution within certain constraints--for example, manpower, facilities, or funding limitations. The analyst should avoid imposing arbitrary constraints, which would in turn unduly limit the number of alternatives available. Such limitation would, of course, simplify the analysis, but it would do so at the expense of possibly excluding potentially valuable alternatives.

E. ESTIMATING COST AND BENEFITS

In practice, the step that is usually most difficult and time-consuming is that of estimating the costs and benefits of each alternative. The analyst must investigate each alternative to determine all the costs and benefits expected during the entire life cycle of the project. The information needed will depend to some extent on the nature of the problem. The analyst must determine what data are needed and provide for their collection. [Ref. 10: p. 2-3]

Costs and benefits are essential for the entire useful life of the project, not simply the first year of acquisition or use. Appropriate estimates must be made by the year in which the cost is to be incurred or the benefit is to be received. The decision-maker should be interested only in the differences in costs of various alternatives; costs that would remain the same under any alternative may be omitted from the analysis (although it is generally a good idea to note this exclusion under the list of assumptions).

Benefits are usually not as easily identifiable as costs, but they still should be quantified to the maximum extent possible. Those intangible benefits that are more difficult to evaluate and quantify, such as "increased morale," or "increased safety," should be identified so far as possible and included in the analysis via a narrative description.

It is important that the analyst research all possible avenues to attaining the objective, to assure that he has obtained the best available cost and benefit estimates. Some costs and benefits may be particularly difficult to estimate. When this occurs, the principle of conservatism should be applied. Conservatism as it pertains to costs involves overstating the cost estimate. Likewise, when benefits or savings are concerned, they should be understated. By being conservative in his estimates, the analyst decreases the risk that the actual outcome will fail to reach the expectations predicted in the analysis. Because acceptance of the analysis depends upon the credibility of the estimates, it is essential that the analyst document all sources and derivations of cost and benefit data. [Ref. 10: p. 2-11]

F. RANKING ALTERNATIVES

In general, economic analysis will be used by managers as an input in selecting the most cost-effective alternative.

Criteria for determining and ranking the cost-effective alternatives include the following [Ref. 11: p. 12]:

- Least-Cost Alternatives. When alternatives for achieving a given mission or objective contribute the same level of benefits, the alternative with the lowest discounted cost or lowest uniform annual cost should be preferred.

- Alternative with Maximum Benefits. As a rule, the best criterion, in cases where benefits and output are a determining factor, is to prefer the alternative that yields the greatest benefits or effectiveness for a given level of cost (discounted). In situations where it is difficult to quantify benefits and measures of effectiveness, it is important to provide as much useful information as possible to enable a decision as to which alternative yields the most benefits or effectiveness.

- Unequal Benefits and Unequal Costs. There is no universally applicable criterion for ranking alternatives in cases where both benefits and costs are unequal. If the benefits of the higher cost alternative are judged to be greater, the analysis should show the extent to which benefits would have to increase to justify the additional cost of that alternative.

These criteria conform to the three basic types of cost/benefit relationships: unequal cost/equal effectiveness, equal cost/unequal effectiveness, and unequal cost/unequal effectiveness.

There could be situations resulting in alternatives having both benefits and cost of equal nature. Preference in these cases would then be determined by noneconomic factors.

The comparison of alternatives is summarized in Table 4-1. [Ref. 9: p. 2-6]

TABLE 4-1. COMPARISON OF ALTERNATIVES

Cost	Benefits	Basis for Recommendation
Equal	Unequal	Greatest benefits
Unequal	Equal	Least Costs
Unequal	Unequal	Highest benefit-to-cost ratio
Equal	Equal	Other factors

Note that the first two criteria for recommendation are really special cases of the third. That is, if all alternatives have the same costs but unequal benefits, then the alternative with the highest benefit measure necessarily has the largest benefit-to-cost ratio. By the same logic, if all alternatives offer comparable benefits but involve unequal costs, then the least-cost alternative has the largest benefit-to-cost ratio. [Ref. 9: p. 2-7]

Techniques that can be used to evaluate and compare alternative include:

- Present-value analysis. Present-value analysis is a means of bringing all future cost and benefits back to their present worths to allow comparable cost comparisons of time-phased costs and benefits. This technique is employed in economic analyses whenever the economic life is greater than three years.

- Uniform annual cost. This is a cost-oriented approach for evaluating alternatives with unequal economic lives.

- Saving/Investment Ratio. This technique displays the relationship between future cost savings (or avoidances) and the investment cost necessary to effect those savings. Because savings are a necessary ingredient, this technique can be employed only when there is a status quo alternative (that is, one which would not result in savings).

- Discounted Payback. This technique determines the period over which accumulated present-value savings will offset the total present-value costs of a proposed alternative. Again, a status quo alternative must be involved.

- Break-Even Analysis. This procedure focuses on calculating the value of a variable at which a manager is indifferent regarding two possible courses of action--that is, the value at which either alternative will produce equal results (either equal levels of effectiveness, equal costs, or equal benefit/cost ratios, depending upon which criteria was chosen to evaluate the alternatives).

- Benefit/Cost Ratio. A means of showing the relationship between output and cost. This technique is used to assess alternatives having unequal cost and unequal benefits.

G. SENSITIVITY ANALYSIS

Uncertainties are always present in analysis. To portray a complete picture to the decision-maker, it is therefore necessary to test the sensitivity of the analysis to dominant cost factors and assumptions .

Sensitivity analysis also provides feedback within the economic analysis process by indicating to the analyst which estimates and assumptions are in need of further refinement. [Ref. 14: p. 7]

By including the results of the sensitivity analysis in the final economic analysis presentation, the analyst assures the decision-maker that the uncertainties have been considered.

V. COST ANALYSIS

A. INTRODUCTION

Cost analysis is an essential element of economic analysis. The quality of an economic analysis depends in large measure upon the quality of the cost analysis performed. Economic analysis is a system which operates on certain input data and provides an output. The best and most complete of systems can yield output only as good as the input data supplied, and economic analysis is no exception to this rule. Solid, well-documented cost input data provide the foundation for the analysis and are absolutely essential to it. Nothing improves the output of an economic analysis more than good input; meaningful conclusions can be drawn only from meaningful cost data. [Ref. 14: p. 46]

B. GENERAL COST CATEGORIES

Costs are normally an essential element of economic analysis since cost constitutes the standard by which most alternatives are compared. Cost is a more complex concept than merely the monetary values associated with various elements of a program. For the purposes of economic analysis, cost can be defined as those benefits foregone by choosing a given alternative. [Ref. 8: p. 7]

However, the costs identified in an economic analysis are very rarely likely to be the same as the budget estimate; they are even less likely to be close to the actual costs should the program be implemented. These differences occur because economic analyses deal with costs in a different way than the actual-cost accounting used once the project is implemented.

Economic analysis is used to weigh and evaluate proposed alternatives by comparing their respective costs and benefits; by contrast, accounting costs measure nothing more nor less than the actual outlays and returns.

A proper understanding of the evolution of analyzing alternatives in terms of their economic costs and benefits requires a basic knowledge of general cost categories.

1. Non-Recurring Costs.

As the name implies, these are one-time costs and are usually associated with the start-up phase of a project. Non-recurring costs may be either additive or nonadditive. Additive costs are unprogrammed or unbudgeted costs of acquiring new resources. Nonadditive costs are the expenses diverted from existing resources. Non-recurring costs include five subcategories: research and development, investment, working capital, value of existing assets employed, and terminal/residual value. [Ref. 9: p. 3-4]

a. Research and Development (R&D)

This first type of non-recurring cost includes those costs resulting from applied research, engineering design, analysis, development, and testing. The effort from which those costs derive includes the conceptual, validation, and full-scale development phases. R&D costs essentially end once an alternative is ready to be introduced into use.

b. Investment Costs

The second non-recurring cost category includes those costs which generally occur only once in the production cycle, investment, acquisition of equipment, real property, non-recurring services, non-recurring operations and maintenance (start-up) costs and other one-time investment costs. These investment costs need not all occur in a single year. They include [Ref. 15: p. 25]:

(1) The cost of rehabilitation, modification or addition of land, buildings, machinery, and equipment.

(2) The costs of rehabilitation, modification, or other capital items. Examples are furnishing and fitting required to put the project on a "ready-to-use" basis.

(3) The cost of plant rearrangement and tooling associated with the project.

(4) The value of non-recurring services received from others.

(5) The costs of freight, foundations, and installations required by the project.

(6) The cost of leaseholds.

c. Working Capital

This non-recurring cost includes money tied up in liquid funds or assets on hand or on order. Generally, working capital is some form of inventory of consumables or similar resources held in readiness for use or in stock. Working capital changes can be positive (representing additional funding requirements) or negative (representing a reduction in funding requirements). Negative changes figures are usually displayed within parentheses ( ) indicating that the reduction in funds is to be subtracted from other investment costs for the alternative. [Ref. 14: p. 48]

d. Value of Existing Employed Assets

This non-recurring cost represents the value of assets already on hand which are to be used with the new project. However, the value of such existing assets shall be included in the investment cost only when one of the two following conditions is met:

(1) When the use of the existing asset will result in a cash outlay on some other project which would otherwise not be incurred --that is, when the existing asset is currently in use (or has an alternative planned use) on some other project.

(2) When the use of the existing asset will deprive the unit of cash planned to be realized by its sale.

When the value of existing assets employed is included, the existing assets should be included at their fair value (as measured by market price, scrap value, or alternative use value), and the basis for arriving at the estimate should be fully documented. [Ref. 14: p. 49]

e. Terminal/Residual Value

In many instances, value can be imputed to an asset no longer in use. This value can be either terminal or residual. Terminal value is defined as the expected value of buildings, equipment, or other assets at the end of their economic lives and is treated as a reduction in the life-cycle cost of the particular alternative for which the use of the asset is intended. Residual value is the computed value of assets at any point in time. Residual value may or may not coincide with terminal value. Terminal/residual value should be applied to existing assets replaced as well as new assets being acquired. Probably the most important criterion for determining the terminal/residual value is what will be done with the asset. The following situations explain this concept: [Ref. 9: pp. 3-6]

(1) Scrap Value of an Asset. If an asset is to be scrapped, then its only value is the scrap value less costs of dismantling and selling it.

(2) Sale of an Asset. If it is sold, the item's value will be the actual price of the item less costs of the sale.

(3) Reutilization of an Asset. In this case, the asset's value is determined by its worth in the market less costs attributed to redistribution.

(4) Continued use of an Asset. Often the need for a service will extend far into the future. When this occurs, the automatic replacement of assets and repeating cash flows will result in a repetitive cycle of expenditures.

2. Recurring Costs

This major cost category includes personnel costs, material consumed in use cost, operating costs, overhead costs, the cost of support services required on an annual basis, and any other recurring costs. Recurring costs occur more or less continuously throughout the life cycle of a project and may be incurred on a daily, monthly, quarterly, semiannual, or annual basis. These costs are determined depending on the individual situation. For a present alternative, historical records provide a guide. For proposed alternatives, where no historical records exist, the analyst can rely on historical costs of similar types of equipment, as well as consultation with machinery and equipment manufacturers and other sources.

3. Life-Cycle Costs.

Economic analysis provides a tool for effective resource allocation only when all the resource implications associated with each alternative--whether they be direct or indirect--are included. Therefore, life cycle costing must be employed. Life cycle cost in an economic analysis is the project's total cost incurred in research, development, production, operation, support, and where applicable, disposal. According to the U.S. Department of Defense:

> Life cycle cost means the sum of direct, indirect, recurring, non-recurring, and other related costs incurred, or estimated to be incurred, in the design, development, production, operation, maintenance, and support of a system over its anticipated useful span. [Ref. 16: p. 1]

Another way of looking at life-cycle cost is offered by William H. Boden:

> Life Cycle cost is the total cost of acquiring the product , establishing the necessary logistical base from which to deploy and use the product, and maintain the product in operable condition over some prescribed period of time. [Ref. 17: p. 5]

4. Sunk Costs

In this major cost category are those costs which have already been incurred or which have been irrevocably committed to a project. Since such costs are incurred regardless of which alternative is chosen, they are not considered in the decision-making process and are therefore disregarded in the economic analysis. Although sunk costs should not be included as part of the cost analysis, a narrative account of such cost is generally made to provide additional background information. [Ref. 8: p. 8]

5. Opportunity Costs

Implicit in the discussion of relevant costs is the concept of alternative use. The alternative value is often referred to as the "opportunity cost" of employing the resources and can be described as those benefits given up because some alternative venture is foregone. One example to illustrate this concept would be the opportunity cost of money:

> $1 has an opportunity cost of $1 because when you spend it you give up the opportunity of buying whatever else the market determines has a value of $1 or, from another viewpoint, it's because the replacement cost of $1 is $1. [Ref. 18: p. 1]

C OTHER COST CONSIDERATIONS

1. Documentation of Costs

There should be sufficient documentation of all cost data to enable those unfamiliar with the project to arrive at essentially the same basic conclusion as the decision-maker. A cost trail that permits validation of all costs should be available. Should someone in the reviewing process be unable to follow the computations and assumptions because of insufficient documentation, the review will be delayed while clarification is being obtained. Such delays might well result in the project being deferred or even disapproved.

Certain basic principles should be used to document the cost estimate. If these principles are followed, the economic analysis will meet the test of being properly documented. The following elements should be covered in the documentation:

- Cost method used
- Inclusion of all relevant costs
- Inclusion of directly related support and training costs
- Exclusion of all sunk costs
- Use of the most accurate sources of cost data available
- Identification of the sources of cost data
- Explanation of the method of arriving at the cost estimates

2. Time Phasing of Costs and Benefits

One of the more important aspects of an economic analysis is the proper time phasing of costs and benefits. If the costs are not properly time phased (by period), the discounted costs or savings will be either over- or understated. A project may involve a single investment expenditure as soon as the project starts. This type of an investment cost does not require any discounting. But if the expenditure is delayed for several months, then the cost should be discounted. Any savings realized would be subject to discounting as well. For example, assume we are thinking of investing in a machine which will be installed in three weeks, and the machine will be paid for upon installation. This expenditure should not be discounted. However, if the expenditure will not occur until two or three months after installation, then the investment cost should be discounted in the economic analysis. [Ref. 15: p. 29]

VI. BASIC ECONOMIC ANALYSIS TECHNIQUES

The techniques explained in this chapter relate to the fifth of the six fundamental steps in economic analysis, namely, the systematic comparison of costs and benefits. The notions developed will be primarily cost-oriented, because costs are almost always easily quantifiable in terms of dollars. However, these techniques are no less applicable to benefits that are expressible in terms of dollars.

A. CASH FLOW DIAGRAMS

The cash flow diagram is a pictorial technique for representing the magnitude and timing of all costs associated with a given economic alternative. It is necessary to draw a cash flow diagram for each alternative being considered in an economic analysis. Figure 6-1 shows a generalized cash flow diagram with a typical pattern of life-cycle costs. The horizontal axis represents a time span. The choice of time unit is arbitrary, but the scale is usually graduated in years. Costs are represented by vertical arrows whose lengths are proportional to the cost magnitudes and whose locations on the time line indicate when they occur. In Figure 6-1, the long arrow on the left (time zero) represents the acquisition or start-up costs, the shorter downward arrows (Years 1-10) represent costs incurred from year to year--for example, operating costs, maintenance costs, and isolated one-time costs. The upward arrow at the right (Year 10) represents the terminal or residual value of assets on hand at that time.

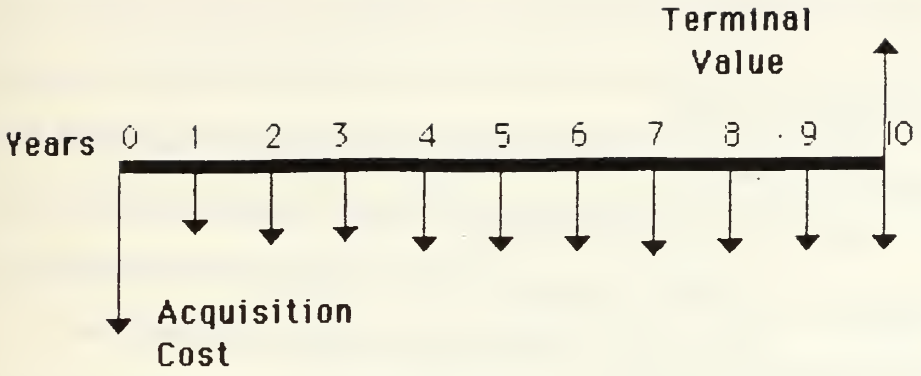


Figure 6-1. Cash Flow Diagram

Because terminal value is to be netted against the total life cycle cost, it acts to offset other costs and is drawn upward. [Ref. 14: p. 12]

B. ECONOMIC LIFE

Implicit in the specification of the costs represented in Figure 6-1 is the period over which they are incurred. The 10-year time frame in that figure is referred to as the economic life of the alternative. The economic life will ultimately be governed by one of three factors:

- The mission life, or period over which a need for the asset or program is anticipated;
- The physical life, or period over which the asset may be expected to last physically;
- The technological life, or period before obsolescence will dictate replacement of the existing (or prospective) asset.

The economic life will generally be the shortest of the mission, physical, or technological lives. The economic lives of the various possible project alternatives will govern the time period covered by the economic analysis. In general, the economic lives of all alternatives should be set so that they start in the same years, and where possible, expend over the same period of time. [Ref. 14: p. 13]

C. INTEREST AND PRESENT VALUE

Money is a claim on productive commodities, and, as such, it commands a price for its use. This price is called interest. Interest is customarily expressed as a percent or decimal, representing the fractional amount of a loan the borrower must pay the lender within a specified interval of time, usually one year. Three concepts are important in calculating interest: simple interest, compound interest, and net present value.

1. Simple Interest

The amount of interest (I) is determined by multiplying the principal amount (P) by the rate of interest (i). This may be expressed as the simple interest formula:

$$I = P*i$$

2. Compound Interest

The notion of compound interest is central to understanding the mathematics of finance. The term itself merely implies that interest paid on a loan or an investment is added to the principal. As a result, interest is earned on interest. [Ref. 19: p. 14] It can be shown that if an amount P is lent today at an annual rate of interest i, the total amount repaid (F) to the lender at the end of n years is:

$$Fn = P(1 + i)^n$$

3. Net Present Value

The basic idea of net present value is simply to find the balance of the trade-off between investment outlays and future benefits, in terms of time-adjusted present value dollars. [Ref. 20: p. 143] The net present value calculation is the last phase in a cost-benefit analysis. The net present value of the alternative must be compared against the expected costs or benefits; it must also be checked for sensitivity to various values that may be subject to change. The following basic principles explain calculation of net present value. [Ref. 8: p. 22]

Essentially, the present value of $1.00 a year from now is $0.954, using 10 percent as the discount rate. A dollar two years hence is worth $0.847 at present, using 10 percent discount. Table 6-1 provides 25 years' of discounted values at 10 percent discount rate.

Table 6-1. PRESENT VALUE OF $1.00, DISCOUNT=10 %

Year	Present Value	Year	Present Value
1	0.951	14	0.276
2	0.954	15	0.251
3	0.847	16	0.228
4	0.717	17	0.208
5	0.652	18	0.189
6	0.592	19	0.172
7	0.538	20	0.156
8	0.489	21	0.142
9	0.445	22	0.129
10	0.405	23	0.117
11	0.368	24	0.107
12	0.334	25	0.097
13	0.306		

The simplest method for computing net present value is to multiply the costs of a given year times the corresponding discount factor listed in Table 6-1 (if 10 percent is being used) The net present value formula can be expressed as follows:

Present value of net benefits = Sum of the net benefits

(net benefits = the benefits minus costs)

each year over the project life

In mathematical terms, NPV is expressed as follows:

$$\frac{\text{(benefits in year 1)} - \text{(costs in year 1)}}{(1.1)^1} +$$

$$\frac{\text{(benefits in year 2)} - \text{(costs in year 2)}}{(1.1)^2} + \text{...(etc.)}$$

Note: 1.1 is the simplified discount factor for a discount rate of 10 percent $[(1+0.1)^t = (1.1)^t]$.

If all costs and benefits have been estimated correctly, then only the projects with positive net present values would be considered.

The net present value concept presented here is only one way to view NPV. Earlier, the discount factor, $(1 =0.1)^t$, was applied to the net benefits (benefits minus costs) in each year. Instead of concentrating on net benefits, analysis could be based on the notion that at every level of resource used, there is one level of output. In other words, the analyst thinks in terms of the resources required to produce a specific level of output. If the resources are expressed as costs, then it is the costs required to produce a specific level of output.

This implies that costs can be expressed as a function of output. That is, costs are dependent on the level of output and the detail of multiple inputs that are subsumed in the relationship of output to cost. This is called the cost function and is expressed as follows:

Cost = F(Output)

If more than one output is expected, the formula is expanded to:

$$\text{Cost} = F(Q1, Q2, Q3, \ldots, Qn)$$

Using the cost function the same way that net benefits were used earlier, net present value of costs can be expressed as a function of output in the following way:

$$\frac{F(Q_1, Q_2, Q_3, \ldots, Q_n) \text{ Year 1}}{(1.1)^1} +$$

$$\frac{F(Q_1, Q_2, Q_3, \ldots, Q_n) \text{ Year 2}}{(1.1)^2} + \text{(etc.)}$$

Essentially, these cost functions can be derived mathematically by using historical data of different output levels to arrive at an equation. Using this technique saves the trouble of researching all the cost details of the multiple inputs required in the net benefit approach.

Which of the two methods to use in solving an decision problem depends on the nature of cost and benefits associated with each alternative. If all costs and benefits are expressed in dollars, and the benefits vary with each alternative, then the net benefit approach is best. If, on the other hand, benefits are not measurable in dollars and can be fixed at a specific level, then the approach to take is that of minimizing costs given that all the alternatives meet the minimum benefits. When a situation such as this occurs, a benefit/cost ratio for each alternative can be used to develop decision rules that identify the least cost alternative. [Ref. 8: p. 26]

D. PAYBACK ANALYSIS

Most simply defined, payback is the period of time required for a project's total accumulated savings or benefits to offset investment costs. For example , if the analyst were to consider a project costing $100, yielding savings of $25 annually, its undiscounted payback period would be four years.

Notably, the economic implication of payback is not affected by the duration of the project's life. Thus, the payback method can be used to establish priorities among competing projects. Projects with more rapid paybacks are usually preferred.

1. Limitations to Undiscounted Payback

The foregoing example is not a true representation of payback, due to two important shortcomings.

First, the 4-year payback represents an undiscounted cash flow. By failing to distinguish the timing of cash flows within a project payoff period, undiscounted payback ignore the important element of the time value of money.

The second weakness of the example lies in its failure to address cash flows beyond a period necessary to recover initial investment costs. If significant one-time costs are to occur after the estimated point of payback, the economic attractiveness of the proposed project will be overstated. A more significant drawback to payback is that it fails to deal with the main reason one invests: that is, to get a return of more than the original investment.

2. Discounted Payback Method

By incorporating a "time value" element and including all future cash flows, the concept can be modified to determine the "disounted payback" period. Thus, payback would be achieved when total accumulated present-value savings are sufficient to offset the total present-value costs of a proposed alternative. The payback period is simply the total elapsed time between the point of initial investment and the point at which payback will occur. [Ref. 10: p. 14-2]

E. SENSITIVITY ANALYSIS

In various types of analytical studies, rather than merely settling for "expected values," the analysts may vary the values of key uncertain parameters or assumptions over their relevant ranges. The purpose of these variations is to examine the impact they may have on final outcomes. This can be useful to decision-makers for many purposes. First, it may help in ranking alternatives. It can highlight which uncertainties are truly important and possibly merit further deliberation--for example, seeking ways to reduce or hedge against such uncertainties.

A special case of sensitivity analysis is the so-called "break-even" analysis. Here, in the case of a key parameter about which we are uncertain, the analysts can calculate the value that must be assumed in order to change the ranking of the most important alternative under consideration. [Ref. 21: p. 3]

Some of the elements which should be scrutinized and evaluated in sensitivity analysis are:

- Cost Estimates--those major cost elements which when increased or decreased have a significant impact on the present-value cost.
- Length of System Life--the effect of a shorter or longer system life.
- Volume, Mix, or Pattern of Workload--variations in the estimated volume, mix, or pattern of workload which affect the present value of cost.
- Requirements--the effects of potential changes in requirements resulting from either legislative mandate or changes in functional or organizational structure.

- Configuration of Equipment or Software--the effects of changes in configuration of equipment, software, data communications, and other facilities.
- Assumptions--the effects of alternative assumptions concerning requirements, operations, facilities, and software, etc.

The basic procedure for sensitivity testing is fairly simple. The analyst should first select the factor to be tested, holding all parameters in the analysis constant except that factor. He should rework the analysis using different estimates for the factor under consideration. He should then check the results. If the ranking of alternatives is affected when the factor is changed, then the analysis is sensitive to that variable. Each key parameter should be tested individually to determine its effect on the analysis. [Ref. 8: p. 30]

F. COST-ESTIMATING TECHNIQUES

A really effective cost analysis capability cannot exist without systematic collection and storage of data and information on past, current, and projected programs. The data and information must be analyzed with a view to development of estimating relationships that may be used as a basis for determining the resource impact of future proposals. In the case of military systems, these relationships should ideally relate various categories of resource impact to system physical, performance, and operational concept characteristics.

A simple definition of an estimating relationship is: a statement of how one variable affects another. In reality, this might be expanded to a statement of how one or more variables affect one another. In certain instances, a simple factor-type relationship may exist that can be expressed as a single number. In estimating pay and allowances, for example, a simple multiplier can be applied to the number of personnel to generate an estimate of their annual pay. On the other hand, estimating relationships can be considerably more complicated where there is intricate interplay between two or more variables and another, such as the relationship between aircraft speed and cost and the cost of depot maintenance for that aircraft. [Ref. 22: p. 44]

1. Benefits of Estimating Relationships

There are, of course, many benefits that result from having available as many reliable estimating relationships as possible. First, naturally, is the fact that much time can be saved if, instead of having to derive a relationship requiring extensive research each time he is presented with a problem, the cost analyst can go to his file, select an appropriate relationship, and apply it. Having estimating relationships available in a formal sense--either mathematical or graphic--can be quite useful in performing "sensitivity analysis." If the analyst states estimating relationships in mathematical form, he can often save some of the required iterations by making an analysis of the relationship itself.

2. Methods

Basically, the estimating techniques can be limited to three: the industrial engineering approach, the statistical approach, and analogy. Estimating by industrial engineering procedures can be broadly defined as an examination of separate segments of work at a low level of detail and a synthesis of the many detailed estimates into a total.

Statistical estimating is sometimes defined as a statistical extrapolation to produce an estimate-at-completion after progress has been made on a a job and costs or commitments have been experienced. In the statistical approach, estimating relationships that use explanatory variables such as weight, speed, power, frequency, and thrust are relied on to predict cost at a higher level of aggregation.

In situations where there are no qualified cost analysts and little historical data, the entire effort must consist of an application of judgment. A special method of judgment is the use of analogies. An analogy is a direct comparison with similar, historical systems/products. A major caution with this process is that it is essentially a judgment process, requiring a considerable amount of expertise and intuitive reasoning. [Ref. 23: p. 2]

VII. MEASURES OF EFFECTIVENESS

A. INTRODUCTION

Cost-effectiveness analysis derives principally from work done in the U.S. Department of Defense during the 1960's. Many of the technical problems of developing military systems were analyzed within some framework of effectiveness and cost considerations. Benefit-to-cost analysis permitted specification of a model with more or less widespread recognition. However, there is no generally accepted model that can be designated as "the cost-effectiveness model."

Methodologically, cost-effectiveness analysis aims at the selection of one or more alternatives from a pool of possibilities, each of which has been designed to meet one or more objectives. Where the time dimension is the dominant or near dominant consideration in the benefit-cost approach, the cost-effectiveness approach ignores time as a structural component.

Cost-effectiveness is a natural substitute for benefit-cost analysis in those situations in which benefits are incommensurable and/or inappropriate for dollar valuation.

Cost effectiveness is usually applied from one of two perspectives [Ref. 24: p. 39]:

- For a given level of effectiveness, searching for the alternative(s) that will minimize cost outlays
- For a given level of cost outlay, searching for the alternative(s) that will maximize effectiveness.

Cost-effectiveness analysis is part of the general theory of maximizing behavior. It shares with the theory of the firm the problem of measuring cost (the problem applies both to private-sector, profit-seeking and to public-sector entities). It shares with operations analysis the problem of choosing an appropriate measure of effectiveness. [Ref. 25: p. 17]

1. Cost-Benefit Analysis

Cost-benefit analysis of a public investment should resemble the analysis of a profit-maximizing business firm; the most important differences between the two are in identification of the costs to be included and excluded and in the problem of measuring benefits. Under some circumstances, the measure of cost should be adjusted to reflect the difference between the opportunity cost and the market price of resources.

2. Cost-Effectiveness Analysis

Cost-effectiveness is specifically directed to problems in which the output cannot be evaluated in market price, although the inputs can, and where the inputs are substitutable at exchange relationships developed in the market. Cost-effectiveness analysis is appropriate when:

- There is no market evaluation of alternative outputs, as in a large portion of the defense sector.
- The resource inputs can be appropriately evaluated at market prices.

3. The Classical Theory of the Firm

The classical theory of the firm represents the businessman as maximizing profits or, more specifically, as maximizing the differences between the discounted stream of revenues and the discounted stream of costs. Both revenue and costs are measured in monetary terms. From the point of view of the firm's objective, output is optimum when marginal revenue equals the marginal cost of producing that revenue.

4. Classical Operations Analysis

Classical operations analysis, at the other end of the spectrum from the theory of the firm, can be conducted entirely in physical and other non-monetary terms. It is addressed to a problem of maximizing effectiveness, subject to a set specific resource constraints, measured in the amount of the several types of resources available. Operations analysis is appropriate where there is no market evaluation of either input or output, as in the scheduling of production with a given set of production resources, or in the choice of tactics for a given combat unit. [Ref. 25: p. 18]

B. COST-EFFECTIVENESS MODEL

The essence of the cost-effectiveness analysis is to construct and operate within a model--that is, a representation that demonstrates how the important elements of a system interact in given situations. The model may take such forms as a mathematically based computer program, a war game simulation, or a set of questionnaires.

The model introduces a precise structure and terminology that serve primarily as a means of communication, enabling analytical participants and users to review data and make judgments in a concrete context.

Through feedback--the results of the computer's computation, the countermove in a war game, the responses to the questionnaires--the model allows decision-makers, analysts, and other experts who may be assisting to focus judgments earlier than would be possible in real time, thus fostering a clearer understanding of the problem and its context.

The central importance of the model can be appreciated most readily perhaps by viewing it in relation to the other elements of analysis. Some writers specify five altogether: objective(s), alternatives, costs, model(s), and effectiveness measurement criteria. Each of the five is present in every analysis of choice, although they may not always be explicitly identified [Ref. 26: p. 4]

1. The Objective (or Objectives)

Cost-effectiveness analysis is undertaken primarily to help choose a policy or course of action. One of the first and most important tasks of the analyst is to define what objectives the decision-maker is--or should be--trying to attain and how to measure the extent to which they are, in fact, attained.

2. The Alternatives

The alternatives are the means by which the objectives can be attained. They need not be obvious substitutes for one another or perform the same specific function.

3. The Costs

The choice of a particular alternative for accomplishing the objectives implies that certain specific resources can no longer be used for other purposes. These foregone opportunities are the costs of that alternative. In analyses for a future time period, most costs can be measured in monetary terms, but their true measure is in terms of the opportunities that they preclude.

4. A Model (or Models)

A model is a simplified representation of the real world that abstracts the features of the situation relevant to the question being studied. In cost-effectiveness analysis, the role of the model is to predict the cost that each alternative would incur and the extent to which each alternative would assist in attaining the objectives.

5. A Criterion

The most widely used criteria for selecting the preferred alternative are usually based on either equal cost or equal effectiveness of the alternatives. When the equal cost form is applied, it is assumed that an arbitrary budget limit has been fixed, and the analysis determines which alternative gives the greatest effectiveness of that fixed level of expenditure.

When the equal effectiveness form is used, a specified and measurable level of effectiveness (capability) is determined, and the analysis determines which alternative achieves this level of effectiveness at least cost.

Another method known as incremental effectiveness at incremental costs is used in special cases. The incremental effectiveness at incremental cost method relates the increase in effectiveness achieved to the associated increase in resources required.

Ultimately, the choice of a criterion for selecting the preferred alternative is the responsibility of the decision-maker. Therefore, the analyst presents the information on cost or effectiveness, as well as their incrementals, in terms meaningful to the decision-maker.

Ideally, cost effectiveness analysis does not make decisions per se. Rather, it provides the decision-maker with data to aid him in making better and more realistic decisions. The decisioin process remains the prerogative of those persons responsible and accountable for the planning and operation of each particular system. [Ref. 18: p. 2]

> It is easy to exaggerate the degree of assistance that analysis can offer a policy-maker. In almost every case, competent cost-effectiveness analysis can help a decision-maker understand the relevant alternatives and the key interactions by giving him an estimate of the costs, risks, and possible payoffs associated with each course of action. In so doing, it may sharpen his intuition; it will certainly broaden his basis for judgment. This almost always helps the decision-maker toward a more informed--and, hopefully, better--decision that he would otherwise be capable of. However, no amount of analysis, regardless of quality, can completely protect against the intrusion of such factors as the decision-makers personal value judgments, imprecise knowledge of the situation, intuitive estimates of enemy intent, and similar defects. In reality, this means that a study can do little more than allow assessment of some of the implications of choosing one alternative over another. In practically no case will the analyst be able to demonstrate unequivocably that a particular decision is best. [Ref. 26: p. 7]

C. MEASURES OF EFFECTIVENESS

A measure of effectiveness (MOE) is a correlator, an estimator, or a predictor of true value of an alternative. When the true value is high, the measure of effectiveness gives a high score, and when the true value is low, the measure of effectiveness gives a low score. However, the analyst cannot rely on this absolutely, because the MOE usually does not correlate or estimate or predict perfectly.

The measures of effectiveness are used for a variety of purposes [Ref. 27: p. 85]:

- To find out how well an existing system works or to find out what an existing system is worth.
- To make an existing system work better the analyst exercises or trains with the system and tries to raise the score.
- To design, select, and prepare to operate future systems so that they will work better.

The MOE provides a numerical measure of a system performance based on this concept. The qualification of "numerical" is not absolutely essential. The measure of effectiveness usually can be implemented in a mathematical or computer model to extrapolate or predict performance. The measure of effectiveness evaluates or predicts aspects of performance relevant to operational issues, and it can be evaluated with available data.

To be useful, a measure of effectiveness must have certain qualities. It should be operationally credible. It should relate clearly to some benefit. It should have some predictive value. It should be sensitive to factors known to influence the value. It should be measurable. The analyst must be able to determine it from available data.

Finally, a good measure of effectiveness must complement some model (analytic, computational, or other) of how the system operates and interacts with the rest of the universe; otherwise the analyst cannot do anything with it. The output must be such that the people who are not operations analysts can use it to support decision-making. [Ref. 27: p. 86]

D. PROBLEMS IN CHOOSING MEASURES OF EFFECTIVENESS

The choice of these measures is the most difficult, unique problem of cost-effectiveness analysis. In choosing a measure of effectiveness, the analyst faces some general problems and others that are specific to particular applications.

One general problem is that real uncertainties always exist. The true value that the measure of effectiveness attempts measures cannot always be determined. Thus it may be impossible to define the value of a measure of effectiveness except by a probability distribution contingent on events that have not yet happened.

In spite of the difficulties in finding useful measures of effectiveness, a great deal can be done. Substantial improvements in data gathering are possible. There are efforts, such as the movement to find social indicators, that may eventually provide better means for taking social factors into account. The first step, of course, is to decide what the analyst wants to measure. To do this, he must know the objective the analysis is to support. The essential mark of a good effectiveness measure is that it closely reflects the objective. [Ref. 13: p. 101.]

E. CONCLUSION

In military cost-effectiveness analysis, measures of effectiveness are at best reasonably satisfactory approximations for measuringthe degree to which various alternatives will achieve such vaguely defined objectives as deterrence or victory. Sometimes the best that can be done is to find measures which point in the right direction. Deterrence is a prime example: it exists only in the mind, and.in the enemy's mind, at that. The analyst cannot, therefore, measure directly the effectiveness of alternatives he hopes will enhance deterrence; he must use instead such surrogates as the potential mortalities an alternative might inflict, or the estimated square footage of roof cover it might destroy.

Moreover, one cannot be as confident about the accuracy of effectiveness estimates as the accuracy of cost estimates. An error in measurement of effectiveness may not be too important in the comparison of systems that are not radically dissimilar--say, two ground-attack aircraft. However, at higher levels of optimization--such as tanks versus aircraft or missiles--gross differences in system effectiveness may be obscured by gross differences in the quality of damage assessment. [Ref. 26: p. 11]

VIII. CONCLUSIONS

Economic analysis concepts and techniques apply to all echelons of operations in forming a solid foundation for decision-making. The process of economic analysis can provide vital documentation of the alternatives in supporting cost-effective decisions (though not necessarily the least priced with respect to total money).

This thesis has described the mechanics of performing an economic analysis. The author recognizes that the guidance stating that the level of effort for an economic analysis study should be commensurate with cost of the analysis will naturally allow a wide variance of application, and non-uniform application of economic analysis. Nonetheless, the author contends that the Venezuelan Navy stands to benefit from initiating a policy of applying economic analysis. Specifically, the Venezualan Navy should undertake the policy modifications necessary to fulfill the following broad goals:

- To insure application of economic analyses in decisions involving the consumption of scarce monetary resources.
- To develop uniform requirements for conducting economic analysis for all activities and appropriations.
- To determine a minimum documentation requirement regarding format and detail for every economic analysis.
- To use the guidelines in this thesis to develop further research in economic analysis for specific activities such as automated data processing, facilities, education, training programs, etc.

Implementing the philosophy presented in this thesis implies that some change has to be made in the procurement criteria and the resource allocation process currently in practice within the Venezuelan Navy. Acknowledging the difficulties of imposing change on any long-standing system, the author contends that the benefits to be garnered from economic analysis will far outweigh the costs and ensure that scarce public resources are put to better use.

APPENDIX A

AN ILLUSTRATIVE APPLICATION OF ECONOMIC ANALYSIS

This appendix presents a specific application of the concepts presented in the main body of this thesis. Extracted from the work of Hitch and McKean [Ref. 28: pp. 133-158], this application will illustrate how the fundamentals of economic analysis can be used in real-world military situations. The appendix is presented in two parts: a specific case in which economic analysis if appropriate, followed by application of the analytical techniques of economic analysis to the problem presented in the example. Linear programming was selected as the primary tool of quantitative analysis.

A. THE PROBLEM

The analysis presented is a real problem of military choice. It is a problem of procurement or force composition--that of choosing in 195X an intercontinental military air transport fleet for the decade 1958-1967. To focus attention on method rather than substance, the alternatives policies are hypothetical. The assumed characteristics of the aircraft under consideration, such as payloads and ranges, do not correspond to those of existing transports. The planes cannot be labeled "turbo props" or "turbojets"; they are arbitrarily designated as hypothetical alternatives, to illustrate the principles and possibilities of systematic analysis.

However, the context is sufficiently realistic and detailed to illustrate the range of complexities, and calculations have been carried out to the greatest extent to complete the illustration.

Attention is focused on the following question: If the United States has an intercontinental airlift capability, what is the most efficient fleet for the mission?

B. ELEMENTS OF ANALYSIS

1. The Mission or Objective

The assumed mission comprises two tasks: routine worldwide resupply of U.S. Military bases at all times, and deployment in the event of a peripheral war. These tasks, while specified in considerable detail, are intended to be representative airlift missions. Both are stated in terms of cargo and passenger tonnages to be delivered via 20 "channels." A channel is specified by an origin and one or two overseas destinations. To allow for changes in routine air resupply needs and in the availability of various aircraft, the 10-year period studied was divided into Period I (four years, 1958-61, inclusive) and Period II (six years, 1962-67, inclusive).

The magnitude of the deployment task is assumed to remain unchanged throughout the 10 years. The magnitude of the routine resupply mission is assumed to increase from about two and on-half times 1954 levels in Period I to about five time 1954 levels in Period II. This assumption of rapid growth in traffic seems justified by trends observed in the past 10 years.

The representative deployment task consists of the movement to Bhangdhad, a hypothetical city in the Far East, of one infantry division (combat echelon) from Travis Air Force Base, California, one fighter-bomber wing from Travis, and two fighter-bomber wings from Tokyo. In addition, one week's supply of fuel and ammunition for the fighter-bomber wings is to be brought in from Manila. This airlift is to be accomplished in 10 days.

2. The Alternative Means

The aircraft considered for the transport fleet were limited, for present purposes, to four: the C-97 (the currently used piston-engined aircraft), the NC-400 (HC standing for "Hypothetical Cargo" aircraft), the HC-500, and the HC-600. The last three aircraft are turbine-engined aircraft, and the higher the "HC-number," the larger the size of the aircraft. Perhaps the best way to summarize the physical characteristics of these aircraft is to show their respective "payload-range" curves, which picture the combinations of cargo and range that are feasible in each aircraft (see Figure A-1). These curves play a major role in the calculation of results.

Some of these aircraft are supposed to be on hand, while others are presumed to be procurable within specified production limits. Table A-1 gives initial inventories and the possibilities of procurement in each of the two periods.

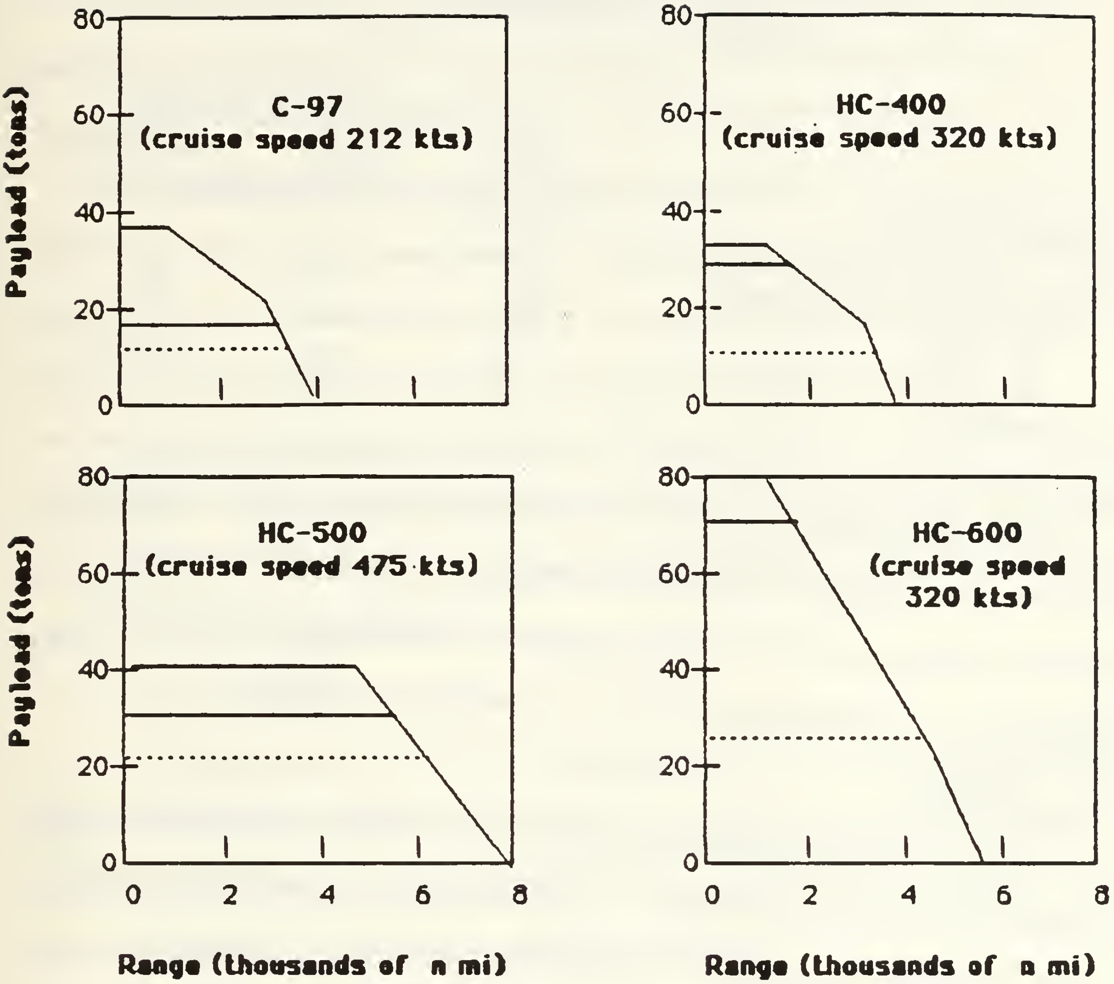


Figure A-1. Payload-Range Curves of the Alternative Aircraft

TABLE A-1. AIRCRAFT AVAILABLE
(ILLUSTRATIVE ANALYSIS)

Aircraft Type	Maximum number procurable Initial inventory	 Period I 1958-1961	 Period II 1962-1968
C-97 (and equivalent	400	0	200
HC-400	100	400	700
HC-500	0	50	100
HC-600	0	0	125

Since the problem pertains to a series of points in time, simplified here to two time periods, the alternatives are not just fleets, but fleet sequences. That is, what the analysis seeks is not actually an optimum fleet but rather the best Period I-Period II sequence of fleets.

3. The Costs

The costs that this example present are the additional system costs attributable to each fleet sequence. It is assumed that six hours of flying per aircraft per day is necessary, expandable to ten hours should the occasion warrant. Hence, in determining fleet costs over the 10=year period, it includes the operating costs of the ten years of 6-hours/day "practice" flying.

There are considered to be four main cost components: procurement, installation and training, attrition, and annual operations.

The procurement cost of an aircraft includes both the cost of the airframe and an initial outlay for spare parts.

Installations and training costs, like procurement costs, are initial, rather than annually recurring costs. The purchase of one particular vehicle for the fleet requires an outlay for building--kitchens, ground-handling equipment, and so on--and for the training of crews and maintenance personnel.

Attrition costs result from peacetime "practice" flying operations. They differ, for present purposes, from other annual operating costs in that they must be paid for by the purchase of replacement aircraft, the cost of which, as indicated above, depends on the total number procured.

Annual operating cost is the most easily dealt with of the four cost components. This cost category is almost directly proportional to the level of the peacetime "practice" flying-hour program and includes such items as wages, fuel, and maintenance.

4. The Criterion

The principal criterion in choosing an alternative will be minimum cost over the years 1958-1967 to maintain the specified airlift capability. The system demonstrating the potential for achieving the objective at the lowest cost will be regarded as the "best" system.

5. The Model and the Procedure

The models comprise the relationships that enable the analyst to estimate the cost and effectiveness of alternative fleets. The technique for finding the least-cost fleet consist of seeking points of tangency between exchange curves and output-isoquants. In other words, the models show how the transport aircraft can be traded for each other while holding total cost constant, and how they can be substituted for each other while keeping the quantity of output constant. The ratio of two aircrafts' marginal costs shows how they can be traded for each other while holding total cost constant. The ratio of the aircrafts' productivities over each channel shows how they can be substituted while keeping the quantity of output constant. Knowing the effects of trading one aircraft for another makes it possible to exchange them until the analysis indicates the least-cost combination that will accomplish the objective.

6. Results and Conclusions

The results are presented in Table A-2. The fleet entailing the lowest costs, which may be called "basic least-cost," employs all three of the new aircraft in Period II (when the HC-600 becomes available). The C-97's are projected to be retired at the end of Period I. Least-cost fleets with certain planes excluded were also calculated.

TABLE A-2. COST AND COMPOSITION OF ALTERNATIVE FLEETS, PERIODS I AND II

	Basic least-cost		Least-cost excluding HC-600		Least-cost excluding HC-500		Least-cost excluding HC-500, HC-600		Least procurement	
(numbers of aircraft)	I	II	I	II	I	II	I	II	I	II
C-97	103	0	0	0	309	0	0	0	400	472
HC-400	151	151	229	229	161	161	399	486	103	103
HC-500	50	53	50	78	--	--	--	--	8	8
HC-600	--	53	--	--	--	113	--	--	--	0
Cost (millions of 1956 dollars)	$3,986		$4,039		$4,295		$4,587		$5,129	

The results in Table A-2 are more sensitive to the employment of the HC-500, for its elimination increases the cost of carrying out the mission by about $300 million. Eliminating both of these aircraft raises the expected cost by about $600 million.

The most striking result, however, is the marked inefficiency that would result from adopting a "least procurement" policy--that is, a policy of buying no more new aircraft than would be necessary to carry out the task. The operating costs of the C-97 are sufficient to make this a very expensive choice (over $1 billion above the least-cost fleet). In this instance, as in many others, it is not economically prudent to "make do" with old equipment. Economizing does not mean minimizing cast outlays in the current time period!

C. LINEAR PROGRAMMING APPLICATION

The foregoing problem was applied against a linear programming model. The input data are shown in Tables A-3 through A-5.

In formulating the linear programming model, the following formulae were used:

Objective Function:

$$\sum_{tij} C_{tj} X_{tji} = K \text{ (min)}$$

where:

K = cost

C_{tj} = period t cost of a j aircraft

X_{tji} = number of j aircraft on channel i in period t

$t = 1,2$

$j = 1, \ldots, 39$

Constraints:

- $\sum_{j} a_{tji} X_{tji} \geq b_{ti}$

  where:

  a_{tji} = productivity coefficient

  b_{ti} = tons required

- $\sum_{i} X_{tji} \leq n_{tj}$

  where:

  n= none available

TABLE A-3. TEN-DAY CARGO AND PASSENGER REQUIREMENTS BY CHANNEL (INCLUDING ROUTINE RESUPPLY, WARTIME DEPLOYMENT, AND WARTIME RESUPPLY

Channel[s]	Passenger tons	Cargo tons
01	--	--
03	--	--
05	50	80
07	25	51
09	25	82
11	31	72
13	45	88
15	--	--
17	557	531
19	--	--
21	--	--
23	111	185
25	27	26
27	44	95
29	10	36
31	112	203
33	74	342
35	45	88
37	--	--
39	--	--
41	26	127
43	538	1,156
45	74	179
47	117	499
57	200	1,000
59	1,600	4,000
61	--	20,000

---

[a] Channels 01-47 are for routine resupply. The requirements for Channels 57-61 are for the tactical deployment in the event of peripheral war.

[b] Nine passengers to a ton. The tonnages listed (for both passengers and cargo) are hypothetical.

TABLE A-4. AIRCRAFT PRODUCTIVITIES BY CHANNEL (TONS PER FLYING HOUR)

Channel	Cargo				Passengers			
	C-97	HC-400	HC-500	HC-600	C-97	HC-400	HC-500	HC-600
5	1.337	3.478	5.321	9.130	.957	1.202	3.946	3.550
7	.404	1.207	2.161	3.160	.365	.471	1.603	1.390
9	.700	1.481	2.922	4.123	.500	.642	2.167	1.895
11	2.114	5.365	7.9968	14.083	1.513	1.854	5.909	5.475
13	.593	1.271	2.649	3.540	.451	.580	1.964	1.712
17	.274	.559	1.513	1.544	.217	.279	1.122	.824
19	.340	.728	0	0	.243	.312	0	0
23	.712	1.583	2.971	4.417	.509	.653	2.203	1.928
25	1.015	2.598	4.139	7.000	.726	.922	3.069	2.722
27	1.000	2.536	4.088	6.912	.717	.910	3.032	2.687
29	.324	.811	1.292	2.211	.231	.291	.938	.860
31	1.146	2.896	4.627	7.863	.819	1.035	3.432	3.057
33	.662	1.355	2.772	3.721	.473	.608	2.056	1.796
35	1.055	2.360	4.288	6.633	.755	.956	3.180	2.824
41	.790	1.84	3.275	5.025	.565	.722	2.429	2.132
43	.272	.756	1.591	2.149	.266	.335	1.180	1.045
45	.219	.467	.959	1.303	.164	.210	.711	.622
47	1.208	3.094	4.642	8.123	.864	1.069	3.442	3.158
57	.494	.968	2.015	2.594	.353	.448	1.494	1.324
59	.182	.358	.840	.959	.138	.176	.623	.520
61	1.604	2.135	5.579	5.720	.780	.988	3.279	2.919

TABLE A-5. COST COEFFICIENTS--COSTS PER
ADDITIONAL AIRPLANE
(MILLIONS OF 1956 DOLLARS)

	C-97	HC-400	HC-500	HC-600*
Period I:				
Operating Cost Coefficient	3.69	3.13	8.13	7.12
Initial Cost Coefficient	0	1.20	3.00	2.68
Total**	2.69	4.33	11.13	9.80
Period II:				
Operating Cost Coefficient	5.54	4.70	12.20	10.68
Initial Cost Coefficient	0	1.80	4.50	4.02
Total**	5.54	6.50	16.70	14.70
Grand Total**	9.23	10.83	27.83	24.50
Initial Outlay for Production	0	0	0	0

* For purposes of comparison, the HC-600 coefficients are given in Period I even though the aircraft is not available in this period.

** The reasons for summing these coefficients, and the conditions under which they can properly be summed, are explained in the section on "Optimizing Procedure."

- $\sum_{i} X_{1ji} - X_{2ji} \leq 0$

  where:

  j = 2(HC-400), 3(NC-500); can't use more in t = 1

- $X_{tji} \geq 0$ (nonnegativity requirement)

C. SOLUTION

The model was run by computer; the results of the program appear on the following pages.

LINEAR PROGRAMING SOLUTION

.DATA ANALYSIS.

1. OBJECTIVE FUNCTION.
COST DATA GIVEN. (REF 27 P 158)
$ 3.69 MILLION FOR THE C-97 IN PERIOD I
5.34 MILLION FOR THE HC-400 IN PERIOD I
12.80 MILLION FOR THE HC-500 IN PERIOD I
5.54 MILLION FOR THE C-97 IN PERIOD II
5.49 MILLION FOR THE HC-400 IN PERIOD II
16.70 MILLION FOR THE HC-500 IN PERIOD II
14.70 MILLION FOR THE HC-600 IN PERIOD II

AGGREGATION OF CHANNELS
THE ORIGINALS 39 CHANNELS WERE AGGREGATED IN 12 CHANNELS AS INDICATED IN THE FOLLOWING TABLE.(L,M,P, PASSENGERS CH.)

CHANNEL	ORIGINAL	TONS	NEW CHANNEL TONS
A	57	1000	1000
B	59	4000	4000
C	61	20000	20000
D	47	499	
	11	72	
	29	36	
	31	203	
	27	95	
	25	26	
	5	80	1011
E	9	82	
	13	88	
	45	179	349
F	33	342	
	43	1156	1498
G	23	185	
	41	127	
	35	88	400
H	17	531	531
K	7	51	51
L	11	31	
	47	117	148
M	17	557	557
P	others passengers channels		2807

DECISION VARIABLES

X1,X2,...........,X12 = PERIOD I A/C C-97,CHANNELS A-P.
X13,X14,..........,X24 = PERIOD II A/C C-97,CHANNELS A-P.
X25,X26,..........,X36 = PERIOD I A/C HC-400,CHANNELS A-P.
X37,X38,..........,X48 = PERIOD II A/C HC-400,CHANNELS A-P.
X49,X50,..........,X60 = PERIOD I A/C HC-500,CHANNELS A-P.
X61,X62,..........,X72 = PERIOD II A/C HC-500,CHANNELS A-P.
X73,X74,..........,X84 = PERIOD II A/C HC-600,CHANNELS A-P.

2. CONSTRAINTS
PRODUCTIVITY COEFF. VS TONS REQUIRED.
PRODUCTIVITY COEFF = TOTAL TONS IN THE AGGREGATED CHANNELS (A-P) OVER THE NUMBER OF A/C REQUIRED IN THE SAME CHANNELS THE INFORMATION IS SHOWN IN THE FOLLOWING TABLE.

PRODUCTIVITY COEFFICIENTS (PERIOD I)

CHANNEL	C-97	HC-400	HC-500	HC-600
A	49.50	97.05	200.00	256.41
B	18.19	35.81	84.03	95.92
C	160.38	213.45	558.66	571.43
D	109.89	280.83	439.57	777.69
E	32.31	68.43	139.60	193.89
F	41.38	84.16	176.24	237.78
G	80.00	181.82	333.33	500.00

H	27.37	55.89	151.71	156.18
K	51.00	127.50	255.00	255.00
L	92.50	113.85	370.00	370.00
M	21.67	27.85	111.40	81.91
P	17.92	22.82	80.20	67.80

PRODUCTIVITY COEFFICIENTS (PERIOD II)

A	49.50	97.05	200.00	256.41
B	18.19	35.81	84.03	95.92
C	160.38	213.45	558.66	571.43
D	55.25	140.42	215.11	374.44
E	16.08	34.22	69.80	96.94
F	20.66	42.08	88.12	118.89
G	39.60	88.89	166.67	250.00
H	13.69	27.95	75.86	76.96
K	24.29	63.75	102.00	170.00
L	47.74	59.20	185.00	164.00
M	10.85	13.96	56.26	41.25
P	14.64	18.62	65.27	55.69

A/C AVAILABLE
THE DATA IS CONTEN IN TABLE A-1 SECTION B IN THIS APPENDIX

A/C PROCUREMENT
THE DATA IS GIVEN IN THE EXAMPLE.

B. SOLUTION

OBJECTIVE FUNCTION

min 3.69x1 + 3.69x2 + 3.69x3 + 3.69x4 + 3.69x5
+ 3.69x6 + 3.69x7 + 3.69x8 + 3.69x9 + 3.69x10
+ 3.69x11 + 3.69x12 + 5.54x13 + 5.54x14 + 5.54x15
+ 5.54x16 + 5.54x17 + 5.54x18 + 5.54x19 +5.54x20
+ 5.54x21 + 5.54x22 + 5.54x23 + 5.54x24 + 5.34x25
+ 5.34x26 + 5.34x27 + 5.34x28 + 5.34x29 + 5.34x30
+ 5.34x31 + 5.34x32 + 5.34x33 + 5.34x34 + 5.34x35
+ 5.34x36 + 5.49x37 + 5.49x38 + 5.49x39 + 5.49x40
+ 5.49x41 + 5.49x42 + 5.49x43 + 5.49x44 + 5.49x45
+ 5.49x46 + 5.49x47 + 5.49x48 + 12.8x49 + 12.8x50
+ 12.8x51 + 12.8x52 + 12.8x53 + 12.8x54 + 12.8x55
+ 12.8x56 + 12.8x57 + 12.8x58 + 12.8x59 + 12.8x60
+ 16.7x61 + 16.7x62 + 16.7x63 + 16.7x64 + 16.7x65
+ 16.7x66 + 16.7x67 + 16.7x68 + 16.7x69 + 16.7x70
+ 16.7x71 + 16.7x72 + 14.7x73 + 14.7x74 + 14.7x75
+ 14.7x76 + 14.7x77 + 14.7x78 + 14.7x79 + 14.7x80
+ 14.7x81 + 14.7x82 + 14.7x83 + 14.7x84

CONSTRAINTS

PRODUCTIVITY COEFFICIENTS CONSTRAINT (24)

49.50x1 + 97.05x25 + 200x49 >= 1000

```
18.19x2 + 35.81x26 + 84.03x50 >= 4000
160.38x3 + 213.45x27 + 558.66x51 >= 20000
109.89x4 + 280.83x28 + 439.57x52 >= 1011
32.31x5 + 68.43x29 + 139.60x53 >= 349
41.38x6 + 84.16x30 + 176.24x54 >= 1498
80x7 + 181.82x31 + 333.33x55 >= 400
27.37x8 + 55.89x32 + 151.71x56 >= 531
51x9 + 127.50x33 + 255x57 >= 51
92.50x10 + 113.85x34 + 370x58 >= 148
21.67x11 + 27.85x35 + 111.40x59 >= 557
17.92x12 + 22.82x36 + 80.2x60 >= 2807
49.50x13 + 97.05x37 + 200x61 + 256.41x73 >= 1000
18.19x14 + 35.81x38 + 84.03x62 + 95.92x74 >= 4000
160.38x15 + 213.45x39 + 558.66x63 + 571.43x75 >= 20000
55.25x16 + 140.42x40 + 215.11x64 + 374.44x76 >= 1011
16.08x17 + 34.22x41 + 69.80x65 + 96.94x77 >= 349
20.66x18 + 42.08x42 + 88.12x66 + 118.89x78 >= 1498
39.60x19 + 88.89x43 + 166.67x67 + 250x79 >= 400
13.69x20 + 27.95x44 + 75.86x68 + 76.96x80 >= 531
24.29x21 + 63.75x45 + 102x69 + 170x81 >= 51
47.74x22 + 59.20x46 + 185x70 + 164.44x82 >= 148
10.85x23 + 13.96x47 + 56.26x71 + 41.25x83 >= 557
14.64x24 + 18.62x48 + 65.27x72 + 55.69x84 >= 2807
```

A/C AVAILABLE (7)

```
x1 + x2 + x3 + x5 + x6 + x7 + x8 + x10 + x11 + x12 <= 400
x13 + x14 + x15 + x16 + x17 + x18 + x19 + x20 + x21 +
x22 + x23 + x24 <= 600
x25 + x26 + x27 + x28 + x29 + x30 + x31 + x32
+ x33 + x34 + x35 + x36 <=500
x37 + x38 + x39 + x40 + x41 + x42 + x43 +
x44 + x45 + x46 + x47 + x48 <= 1200
x49 + x50 + x51 + x52 + x53 + x54 + x55 + x56
+ x57 + x58 + x59 + x60 <= 50
x61 + x62 + x63 + x64 + x66 + x67 + x68 + x69
+ x70 + x71 + x72 <= 150
```

```
x73 + x74 + x75 + x76 + x77 + x78 + x79
+ x80 + x81 + x82 + x83 + x84 <= 125


A/C PROCUREMENT (2)

x25 + x26 + x27 + x28 + x29 + x30 + x31 + x32
+ x33 + x34 + x35 + x36 - x37 - x38 - x39 - x40
- x41 - x42 - x43 - x44 - x45 - x46 - x47 - x48 <= 0
x49 + x50 + x51 + x52 + x53 + x54 + x55 + x56 + x57
+ x58 + x59 + x60 - x61 - x62 - x63 - x64 - x65 - x66
- x67 - x68 - x69 - x70 - x71 - x72 <= 0

LP OPTIMUM FOUND  AT STEP    57

OBJECTIVE FUNCTION VALUE

1)          4260.13281

VARIABLE          VALUE          REDUCED COST
      X1           0.0               0.965321
      X2           0.0               0.976477
      X3         103.506485          0.0
      X4           0.0               1.599643
      X5           0.0               1.167706
      X6           0.0               1.063422
      X7           0.0               1.339534
      X8           0.0               1.371090
      X9           0.0               1.553191
     X10           0.0               0.476609
     X11           0.0               1.182920
     X12           0.0               0.816625
     X13           0.0               5.540000
     X14           0.0               2.752337
     X15           0.0               1.416498
     X16           0.0               3.380688
     X17           0.0               3.101628
     X18           0.0               2.985523
     X19           0.0               3.211521
     X20           0.0               2.925097
     X21           0.0               3.448976
     X22           0.0               1.272319
     X23           0.0               2.332278
     X24           0.0               1.794208
     X25          10.303967          0.0
     X26         111.700638          0.0
     X27           0.0               0.430996
     X28           3.600044          0.0
     X29           5.100102          0.0
     X30          17.799423          0.0
     X31           2.199978          0.0
     X32           0.0               0.606768
     X33           0.400000          0.0
     X34           0.0               1.386946
     X35           0.0               2.119956
     X36           0.0               1.684627
     X37           0.0               5.487977
     X38          49.405579          0.0
     X39          93.698746          0.0
     X40           7.199829          0.0
```

```
X41         0.0                 0.298853
X42         0.0                 0.285052
X43         0.0                 0.261246
X44         0.0                 0.149295
X45         0.300000            0.0
X46         0.0                 0.195837
X47         0.0                 1.354314
X48         0.0                 0.723862
X49         0.0                 1.344762
X50         0.0                 0.318241
X51         6.085329            0.0
X52         0.0                 4.491949
X53         0.0                 1.955629
X54         0.0                 1.666803
X55         0.0                 3.060060
X56         3.500098            0.0
X57         0.0                 2.169522
X58         0.400000            0.0
X59         5.013501            0.0
X60        35.001068            0.0
X61         0.0                16.699997
X62         0.0                 3.822177
X63         0.0                 2.336389
X64         0.0                 8.292943
X65         0.0                 6.115515
X66         0.0                 5.804516
X67         0.0                 6.899802
X68         0.0                 2.210109
X69         0.0                 7.919240
X70         0.0                 0.162064
X71         9.900991            0.0
X72        43.005981            0.0
X73         0.0                14.700000
X74        23.256729            0.0
X75         0.0                 0.008063
X76         0.0                 0.065919
X77         7.600165            0.0
X78        12.599882            0.0
X79         1.599999            0.0
X80         6.899689            0.0
X81         0.0                 0.065405
X82         0.900024            0.0
X83         0.0                 2.464358
X84         0.0                 0.451148

ROW      SLACK OR SURPLUS       DUAL PRICES
 2)         0.0                -0.055044
 3)         0.0                -0.149177
 4)         0.0                -0.023008
 5)         0.0                -0.019022
 6)         0.0                -0.078065
 7)         0.0                -0.063475
 8)         0.0                -0.029381
 9)         0.0                -0.084725
10)         0.0                -0.041898
11)         0.0                -0.034739
12)         0.0                -0.136827
13)         0.0                -0.153253
14)         0.0                -0.025711
15)         0.0                -0.039083
16)         0.0                -0.151640
17)         0.0                -0.123644
18)         0.0                -0.058800
19)         0.0                -0.191008
20)         0.0                -0.086086
21)         0.0                -0.089394
22)         0.0                -3.306931
23)         0.666872            0.0
24)       600.000000            0.0
25)      1048.89575             0.0
26)         0.0                 0.053566
```

```
      27)         97.093018          0.0
      28)         76.143494          0.0
      29)          0.0               0.002023
      30)          2.906974          0.0
      31)          0.0               0.0
      32)          0.085650          0.0
      33)          0.029733          0.0
      34)          0.0              -0.255860

NO. ITERATIONS=       57
```

C. RESULTS AND CONCLUSIONS

THE RESULTS ARE PRESENTED IN THE FOLLOWING TABLE

	I	II
C-97	103	0
HC-400	151	151
HC-500	50	53
HC-600	--	50

COST: 4260 (MILLIONS OF DOLLARS)

THESE RESULTS CONFIRM THE RESULTS OBTAINED IN SECTION B OF THIS APPENDIX, THE DIFFERENCE IN COST IS CAUSED BY TAKING DIFERENT COST DATA AS SPECIFIED IN PAGE 158 OF THE REFERENCE.

REFERENCES

1. Hopkins, John, The Economic Development of Venezuela, The John Hopkins Press, Baltimore, MD, 1966.
2. Allen, Loring, Venezuela Economic Development, A Politico-Economic Analysis, JAI Press, 1977.
3. Blusstein, Howard, Area Handbook For Venezuela, U.S. Government Printing Office, Washington, DC, 1977.
4. Congreso de Venezuela, Constitucion de la Republica de Venezuela y Disposiciones Transitorias, Gaceta Oficial no. 662, Caracas, Venezuela, Enero 23, 1961.
5. Armada de Venezuela Directiva General, Formulacion del Presupesto Annual, Dir-PR-664-001, Caracas, Venezuela, October 1978.
6. Ministerio de la Defensa de Venezuela Directiva NO DMD-EMC-715-02, Politica de Adquisicion Para Systemas y Equipos de Defensa Para Las Fuerzas Armadas, Caracas, Venezuela, Junio 1975.
7. Armada de Venezuela Directiva General, Proceso de Adquisicion, Modificacion y construccion de Unidades de Combate, de Apoya y de Infraestructura y Systemas en General Para la Armada, Caracas, Venezuela, Abril 15, 1985.
8. Gardner, P. J., Handrop, R. S., and Nichols, C. T., Economic Analysis for ADP, Thesis, Naval Postgraduate School, Monterey, California, September 1984.
9. Zimmerman, Denise, Economic Analysis Procedures for ADP, Naval Data Automation Command, Pub. 15 7000, March 1980.
10. U.S. Department of Defense, Economic Analysis, Defense Logistics, DCAM 7041.1, May 1985.
11. U.S. Department of Defense, Economic Analysis and Program Evaluation for Resource Management, DODI 7000.14B, October 1972.
12. U.S. Department of Defense, A need for Uniform Application of Economic Analysis, Defense Logistic Agency, LD 55305A, September 1983.
13. Quade, E. S., Analysis for Public Decisions, 2nd ed., Elsevier Science Publishing Co., Inc., 1982.

14. U.S. Department of Defense, Economic Analysis Handbook, Defense Technical Information Center, AD A140322, July 1980.

15. U.S. Department of Defense, Economic Analysis Handbook, Defense Logistic Agency, LD 61516A, June 1984.

16. U.S. Department of Defense, Major System Acquisitions, DODI 5000.1, March 19, 1980.

17. Boden, William, H., Designing for Life Cycle Cost., Defense Management Journal, January 1976.

18. Horton, F., MN 4145, graduate-level course, Policy Analysis, course notes., Naval Postgraduate School, Monterey, California, 1985.

19. Van Norne, James C., Financial Management and Policy, Sixth Edition, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1968.

20. Helfert, Erich A., Techniques of Financial Analysis, 5th ed., Richard D. Irwin, Inc., 1982.

21. Fisher, G. H., The Nature of Uncertainty, a paper presented at the U.S. Department Defense symposium on Cost Research, Airlie, Virginia, November; sponsored by The Rand Corporation, Santa Monica, California.

22. Petruschell, R. L., The Derivation and Use of Estimating Relationships, The Rand Corporation, RM-3215-PR, June 1962.

23. Batchelder, C. A., Boren, H. E., Campbell, H. g., Dei Rossi, J. A.,and Large, J. P., An Introduction to Equipment Cost Estimating, The Rand Corporation, RM-6103-51, December 1969.

24. Temkin, Sanford, "Making Sense of Benefit Cost Analysis," Improving Human Performance, v. 3, 1974.

25. Niskanen, William A., Measures of Effectiveness, Washington Operations Research Council, Cost Effectiveness Analysis, Edited by Thomas A., Godman, Frederick A., Praeger, Publishers, 1967.

26. Quade, E. S., Cost-Effectiveness Analysis, Washington Operations Research Council, Thomas A. Goldman, ed., Frederic A., Praeger, 1967.

27. Raisbeck, Gordon, "How the Choice of Measures of Effectiveness Constrains Operational Analysis," Interfaces, v. 9, No. 4, August 1979.

28. Hitch, Charles J. and McKean, Roland N., The Economics of Defense in the Nuclear Age, The Rand Corporation, 1978.

BIBLIOGRAPHY

Colmenares, Carlos, A Comparative Analysis of the Budget Process in the Venezuelan and U.S. Navies, Master's Thesis, Naval Postgraduate School, Monterey, California, December 1979.

Fisher, Gene, Cost Considerations in Systems Analysis, The Rand Corporation, 1974.

Leon, Jose, Naval Ships Acquisition Strategy for the Venezuelan Navy, Master's Thesis, Naval Postgraduate School, Monterey, California, June 1982.

Rojas, Jose G., An Approach to the Application of Life Cycle Cost Concept in Weapon Systems Acquisition for the Venezuelan Navy, Master's Thesis, Naval Postgraduate School, Monterey, California, December 1982.

Shadah, Alberto, Organization Development: An Approach for Achieving Desired Organizational Goals Within the Venezuelan Navy, Master's Thesis, Naval Postgraduate School, Monterey, California, June 1982.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22314-6145	2
2.	Defense Logistics Studies Information Center U.S. Army Logistic Management Center For Lee, Virginia 23801	2
3.	Department Chairman, Code 54 Department of Administrative Sciences Monterey, California 93943	1
4.	Professor Fenn Horton, Code 54Hn Department of Administrative Sciences Naval Postgraduate School Monterey, California 93943	1
5.	Professor Leslie Darbyshire, Code 54Da Department of Administrative Sciences Naval Postgraduate School Monterey, California 93943	1
6.	The Naval Attache Embassy of Venezuela 2409 California Street, NW Washington, DC 30008	1
7.	VA Andres Brito Martinez Corandancia General de la Armada Caracas 1010 Venezuela, South America	1*

---

* Via Office of the Naval Attache
Embassy of Venezuela
2409 California Street, NW
Washington, DC 30008

8. VA Alejandro Lander Landaeta 1*
Comandancia General de la Armada
Caracas 1010 Venezuela, South America

9. CA German Rodriguez CitrarO 1*
Comandancia General de la Armada
Caracas 1010 Venezuela, South America

10. CA Cipriano Salazar Aquino 1*
Comandancia General de la Armada
Caracas 1010 Venezuela, South America

11. Jefatura de Educacion 1*
Comandancia General de la Armada
Caracas 1010 Venezuela, South America

12. CF Marco Jimenez Ferrer 1*
Comandancia General de la Armada
Caracas 1010 Venezuela, South America

13. CDR Kristin G. Hinds, USNR
Office of the Chief of Naval Operations (OP-09R4) 1
Department of the Navy
Washington, DC 20350

14. CN Mario Yanez 1
8800 N.W. 15th Street
Miami, Florida 33172

15. Library, Code 0142 2
Naval Postgraduate School
Monterey, California 93943-5000

17898 2

MONTEREY, CALIFORNIA 9394

Thesis
J5404
c.1

218762

Jimenez
Economic analysis: an approach to provide basic guidance for conducting and reviewing economic analysis within the Venezuelan Navy.

Thesis
J5404
c.1

218762

Jimenez
Economic analysis: an approach to provide basic guidance for conducting and reviewing economic analysis within the Venezuelan Navy.

Economic analysis: an approach to prov
3 2768 000 67068 1
DUDLEY KNOX LIBRARY